AN ANALYSIS OF THE ABILITIES OF PROFOUNDLY DEAF CHILDREN

by

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May 1967

"To make words serviceable to the end of communication, it is necessary that they excite in the hearer exactly the same idea they stand for in the mind of the speaker. Without this, men fill one another's heads with noise and sounds; but convey not thereby their thoughts, and lay not before one another their ideas, which is the end of discourse and language."

John Locke (1689)
An Essay Concerning Human Understanding
Book III

CONTENTS

CONTENTS

List of Tables

List of Figures

List of Appendices

PREFACE

A National Survey of the abilities of profoundly deaf children was comissioned by the Donaldson Trust, Edinburgh in 1963 and still continues. This survey has registered the performance of selected samples of profoundly deaf children on a wide range of sensory, personality and cognitive tests and ratings together with some sociological background data and details derived from medical records. The following study is mainly based on the results of the cognitive aspects of the survey data and is further limited to the 219 profoundly deaf children from ten Scottish schools who have been subjected to tests and follow-up enquiries to date.

The writer would like to record his appreciation of the initial backing and subsequent financial support of the Donaldson Trust without which this research would not have been undertaken: in particular the project owes much to the initiative of Dr. Mary Collins whose sustained interest in this field has always been a source of encouragement and example. A further acknowledgement should be made to the University Computer Unit for the provision of local computer facilities, instruction and guidance and to the Applied Psychology Unit, University of Edinburgh for the provision of psychometric material. More directly the writer is indebted to Mr. Denis McMahon of the Applied Psychology Unit for guidance during the course of this investigation and for his introduction to the practical techniques of vocational assessment which here have been adapted to the needs of the deaf. Another debt is to Miss Rae Borthwick who typed the script and tabulation of results.

A more general acknowledgement should also be made to the many Teachers of the Deaf who assisted by providing testing facilities and validation and

follow up data. Inevitably any protracted psychometric examination by means of individual tests is difficult to fit into a school timetable and presents no small inconvenience to teaching staff. But no complaints were registered and the writer is indebted for the unstinted assistance and hospitality which transformed what might have been routine psychometric visitations into agreeable excursions.

Finally, it would not do to forget the subjects of these investigations whose positive attitude to testing was not wholly expected. Their courteous cooperation was at once a credit to their upbringing and a reflection of their evident preference for individual treatment: either way it greatly helped them to meet the demands of a very comprehensive test programme.

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1967

INTRODUCTION

A good deal of research into the abilities of "the deaf" is vitiated by a loose definition of deafness. Many "deaf" people are able to benefit from the use of auditory amplification devices and acquire language and education in much the same way as anyone else. The following investigation is not concerned at all with this larger deaf population but deals only with the prelingually, profoundly deaf, a group whose abilities and educational needs differ greatly from those with later or lesser deafness. A working definition of this special group may be derived from their unique educational requirements which are provided by specialist teachers qualified to deal with the particular speech and language difficulties which arise in this group along with the more obvious handicaps due to auditory deficiency. More rigorous definitions of this kind of deafness appear below and the manner in which research findings may be devalued by uncertain sampling of ambiguously "deaf" populations is suggested. Results validated against a loosely defined "deaf" population may not hold good for the strictly defined profoundly deaf group and to a considerable extent the following study is but an extended definition of this special deaf group together with a plea that their particular differences should be recognised, their particular problems understood and their particular needs met.

Psychometrics and the Deaf

Profound deafness is a relatively rare condition and the very small number of profoundly deaf children is at once an asset and a liability to this investigation. On the debit side small numbers mean that a long term project is needed to provide sufficient cases for statistical treatment while on the credit side it is an unusual privilege to apply psychometric techniques to populations rather than samples: two complete age groups are included in the survey "sample".

Particular care has been taken in obtaining this survey sample in order to avoid the distortion, observed in some previous studies, which derive their test sample from one school. Many schools for the deaf are selective in a number of ways not always immediately obvious. For example, the less well-behaved children are more likely to be placed in a boarding school simply because they are more difficult to care for at home. Again, the day schools and units for the deaf tend to favour integration with hearing children and the transfer of non-oral children to boarding schools, although not an official policy, is not viewed with regret when it happens. Another example may be found in the difference in admission standards of intelligence. Many schools for the deaf tolerate pupils with an intelligence quotient below the conventional acceptance level for ordinary schooling on the decently humanitarian grounds that many such pupils are thus better placed than in institutions for the mentally handicapped where no special facilities for deaf children exist. On the other hand some schools feel a need to maintain educational standards by working to rule on their terms of reference as schools for the deaf and excluding children with multiple handicaps whenever they are permitted to do so.

In some cases partially deaf children of low intelligence do not develop good speech and are placed in classes for the profoundly deaf and vice-versa extremely intelligent deaf children may be so advanced as to profit by education in a school for the partially deaf or in rare cases in an ordinary school. This promotes a sampling hazard for the investigator who is content to accept current educational classifications as a means of selection and definition of a "deaf" sample. But the problem is yet more complex due to the "uncertainty principle" which operates between audiometric and psychometric testing of many unintelligent or very young deaf children whereby the results of psychometric tests must be evaluated according to hearing loss and this in turn is difficult to establish if some mental handicap exists. The interdependence of audiometric and psychometric assessments creates clinical problems in cases of multiple handicap and the occasional misdiagnosis of deafness as mental defect leads to tragic results which could be avoided if ascertainment clinics acquired the services of psychologists.

Psychometric assessment of the deaf demands some specialisation from psychologists as techniques of administration and instructions differ even when the actual test materials do not: the Snijders-Oomens (1959) and Edna Levine (1960) have discussed the particular pitfalls to be avoided in testing the deaf in order to achieve valid results. Some typical problems may be given for example. The guessing of responses which occurs when deaf children over-reach their level of difficulty derives from their training in speech and lip reading where it is often profitable to approximate and to make a guess to preserve continuity rather than to come to a halt. Another transfer effect from special training is the alert cue-seeking from sources other than formally given in test items. The expression of the tester's face may be used in confirmation of the correctness of a response while too obvious an attempt at a "poker-face" may be interpreted as a negative indication which may cause the child to abandon a correct response. Another invalidating circumstance is the ease and rapidity with which deaf children are able to transmit results to each other by means of manual signs if group tests are used. In the majority of cases special tests devised for or adapted to the deaf are preferable to more familiar psychometric instruments. Some apparently non-verbal tests have verbal instructions and, even in tests devised for the deaf, inner verbalising may aid non-verbal tasks. For example, the test of perceptual speed (Test 20) described below consists of non-verbal material but the slight delay between stimulus and response enables a classification of subjects into those who use manual signs to remember the stimulus, those who show no overt indications and those who aid memory by overtly vocalising the numerical stimulus in its verbal form.

Aims and Scope of the Investigation

The main aim of this study has been to examine the nature of language attainments in relation to communication skills, residual hearing and intelligence in the profoundly deaf.

Previous work in the assessment of the abilities of the deaf had indicated the futility of attempting to establish the interrelationships and structure of abilities on a narrow front. The interaction between abilities is very considerable and some partialling technique is essential to take into account other influences while examining particular associations. But the partialling of a few assumedly relevant variates very often misses many other very substantial influences. For example, speech ability in the deaf has been found to correlate substantially with age of onset and extent of hearing loss, with intelligence, scholastic attainments, social grouping, aetiological category of deafness, personality and educational background. In the main test battery of the present study, a written language assessment was found to correlate significantly with 20 out of the 24 variates recorded, a lipreading test was found to correlate with 21 of the same variates and a test of numerical ability employing a slight verbal content (Vernon) registered significant correlations with all variates save residual hearing. Thus no narrow view of the abilities of the deaf was considered worthwhile and the broad, comprehensive approach outlined below was adopted.

The statistical techniques employed to condense the data from the extensive results of test batteries are mainly parametric and correlational. The most thorough-going psychometric assessment was the 15+ battery which involved some 1380 individual or virtually individual tests, apart from audiometric assessment and the extraction of ratings and occupational follow up data. The results of this protracted examination were assembled in a correlation matrix and subjected to factorial analysis. The factors which emerged had obvious affinities with the familiar g, v and n factors found in hearing populations but the unusual inclusion of particular tests of abilities such as hearing, manual communication and lipreading produced unusual groupings of variates in some unfamiliar factors. For this reason factors are not denoted by the usual letter symbols in this study. However much the verbal factor approximates to the familiar v of other studies this does not justify an equation of the two which are derived from populations differing greatly in verbal ability.

The factorial essay in the interaction of the abilities of the deaf is followed by divergent studies in particular abilities which each separately employ some subsidiary analyses and attempt to relate findings to previous research in the pertinent literature. The results of these investigations are then applied to some current educational issues and finally a number of clinical applications are described.

Except for some references to previous literature this work has been strictly restricted to the profoundly deaf and comparisons with hearing or partially deaf samples have not been made. The problems within the deaf population may be tackled in their own right apart from such comparisons which may often be as misleading as enlightening. Besides this practical consideration it is probable that, in the last resort, theoretically valid comparisons cannot be made. The comparison of hearing with the deaf is essentially a cross-cultural comparison and many of the difficulties of using psychometric instruments in alien cultures apply, among which uncertain motivation and widely different response patterns to the same test items indicate that the test conditions are not comparable between groups and hence validity must be established with reference to norms derived from within groups.

This rather purist viewpoint seems to have been abandoned for practical placement purposes in the parts of the following study concerned with the applications of results but in fact it is not incompatible with a belief in the cultural relativism of test results to assess a member of one culture by the standards of another in order to estimate his chances of adapting to this other culture.

A rather limiting feature of this cultural relativist approach has been that it does not encourage the, possibly fruitful, discussion of the implications of the present findings with regard to some other studies which on apriori grounds would seem to be relevant. Thus the very slight reference to the work on sensory deprivation by Hebb and Vernon and the auditory perception studies of Broadbent scarcely does justice to the possibilities of a wider, more general treatment which would relate the theoretical aspects of these various studies to the present work. But the present writer is less than optimistic about this possibility and has found that any facile equation of the deaf with a natural non-verbal experimental group in linguistic studies or regarding them as convenient custodians of a Hebbian "A" intelligence relatively uncorrupted by intelligence "B" can be extremely misleading. The verbal acquisitions of the deaf are no less real for being largely non-oral and they have developed so many esoteric communication skills that their abilities in general differ so much from their hearing age-mates that comparisons must be made guardedly and with careful qualifications.

In the literature on the psychology of deafness there is no lack of racy analogies with the theoretical content of related disciplines and an uncritical readiness to apply the latest preoccupations of psychologists and fashions in education to the problems of the deaf has been noted. Partly as a reaction to works with too much theorising from too few facts, the present study has primarily sought to provide the ground work of information upon which more accurate generalisations may be made rather than to present a contribution of any theoretical worth. This rather heavy empiricism may help to outweigh the disproportionate amount of literature which encourages an inspirational, aspirational and anecdotal approach. At worst this factual tendency in the present work inclines it towards the technology of psychometrics and the production of test instruments, norms, charts and clinical techniques but, in defence, it may be noted that the present work is but a cross-section of a continuing survey and chronologically if not otherwise empirical fact-finding must needs take precedence over the development of a satisfactory theory which accounts for all the information available.

METHOD OF INVESTIGATION

Population

The deaf are commonly regarded as a homogeneous group simply defined by their most obvious feature which is defective hearing. In fact, this larger deaf population comprises many sub-groups with widely different abilities and handicaps (Taylor, 1967). There are, for example, many such differences between the congenitally deaf and the person with later "adventitious" deafness; between those whose hearing impairment is sited in the central nervous system and those with peripheral impairment of the auditory receptor organs; between the partially deaf and the profoundly deaf. The differences in abilities of different sub-groups is so pronounced, especially where tests are influenced by linguistic development, that any study of the abilities of the deaf which does not allow for, or at least record, the age of onset, type and degree of deafness scarcely deserves to be taken seriously.

Especially separable from other deaf groups are those who were profoundly deaf before the development of language in infancy and it is with this particular sub-group, the prelingually, profoundly deaf that the present study is solely concerned. Children who are too deaf to hear their own voices are unable to monitor the speech sounds which they utter and the lack of auditory feed-back precludes the development of naturally acquired speech. In the absence of speech, language in general is seriously underdeveloped and this is reflected in a retardation in written language and almost all school subjects with the possible exceptions of sports, arts and craft skills.

The current educational classification of deaf school children in Scotland adopts a combined speech-hearing criterion to identify "Grade III" deaf children who are described as:-

"Children whose hearing is so defective and whose speech and language are so little developed that they require education by methods used for deaf children without naturally acquired speech or language. This grade includes the totally deaf."

This definition, although somewhat logically circular, is soundly based on educational realities and the Grade III group is, for all practical purposes, the same as the prelingually, profoundly deaf group which has been more rigorously defined for the purposes of the present investigation.

In some studies (see page 52 below) the population-defining residual hearing variate has been left uncontrolled presumably with direct effects upon the abilities under examination. For whenever partially or adventitiously deaf are included in the sample, bias occurs and results are not applicable to the strictly defined profoundly deaf population. A further discussion of what constitutes a realistic audiometric cut-off point for the profoundly deaf population is given on page 118 but at this point it may be sufficient to observe that each sub-sample studied in the present work is statistically defined according to age, articulation loss and hearing loss.

The total survey sample consists of 219 deaf children born in Scotland between the years 1947 to 1958. These children are drawn from seven schools for the deaf, two units for the deaf in ordinary schools, one deaf department in a school for the handicapped, one commercial college and one hospital for the mentally handicapped.

The total sample is divisible into more meaningful groups for detailed investigation and these groups are lettered A to H for reference in this paper. TABLE 1 gives a statistical description of the survey sample and its constituent sub-samples A to H. Apart from A, B and C the sub-samples are not mutually exclusive and the figures in brackets following the sub-sample totals denote the extra cases in each sub-sample which have not featured in preceding sub-samples recorded in the table.

Group B includes the complete year group of all Grade III children born in Scotland in 1951 and group C includes all the Grade III children born in Scotland in 1948.

Groups C2 and C3 are further sub-divisions of Group C and similarly, D2 is a part of Group D. No separate mean hearing loss and articulation loss has been calculated for Groups E to H which are largely composites of preceding groups with these values recorded.

TABLE 1

Group	Tests	Age Range		n			$\bar{x}$		σ
		From	To	Boys	Girls	All	SPAL %	HL	%
A	8+ battery	7.6	9.0	19(19)	14(14)	33(33)	-	94.4	8.8
B	12+ battery	11.4	12.10	44(44)	20(20)	64(64)	41.0	95.1	8.4
C	15+ battery	15.6	16.2	37(37)	33(33)	70(70)	38.8	96.1	6.8
C2	15+ concepts	15.6	16.2	24	18	42	38.0	95.2	7.5
C3	15+ 100% HL	15.6	16.2	12	10	22	48.5	100.0	0.0
D	Audio-analysis	10.6	16.2	55(11)	28(9)	83(20)	41.6	95.1	7.6
D2	Audio-analysis 100% HL	10.6	16.2	15	6	21	51.2	100.0	0.0
E	Speech Analysis	7.6	15.11	38	22	60	S I M I L A R		
F	Matrices Test	11.4	16.2	59(3)	49	108(3)	T O		
G	Phoneme Count	7.6	16.2	130(19)	87(10)	217(29)	CONSTITUENT		
H	Audiograms	7.6	16.2	133	86	219	G R O U P S		
Total Survey Sample		7.6	16.2	133	86	219	A B O V E		

Instrumentation

The main test variates and categories used in computation are listed below and numbered 1 to 62 for reference. They are:-

1. SON Completion (Sub-test 5)
2. SON Drawing (Sub-test 7)
3. SON Sorting (Sub-test 8)
4. SON Block Design (Sub-test 1)
5. SON Picture Memory (Sub-test 2)
6. SON Picture Series (Sub-test 3)
7. SON Figure Analogies (Sub-test 4)
8. SON Knox Cubes (Sub-test 6)
9. McComisky 3D Form Board
10. Raven's Progressive Matrices (1938) (20 minute version)
11. A.P.U. Attribute Analysis
12. A.P.U. Abstractions Test
13. The Donaldson Lipreading Test
14. The Phoneme Count (Speech)
15. The Mill Hill Vocabulary Scale Form 1 Junior Set A Definitions
16. The Mill Hill Vocabulary Scale Form 1 Junior Set B Synonyms
17. Picture Vocabulary, Form A
18. Picture Vocabulary, Form B
19. Visual Word Discrimination Test (Schonell)
20. Number Perception Test
21. Four Rules, Non-verbal Arithmetic Test
22. Vernon's Graded Arithmetic-Mathematics Test

23. Oral Comprehension: Teachers' Rating of Lipreading Ability

24. Voice Production: Teachers' Rating of Speech Intelligibility

25. Written Composition: Teachers' Rating of English Composition

26. Manual Communication: Teachers' Rating of Ability in Fingerspelling

27. Word Score (Speech)

28. Q.D. Qualitative Diagnosis (Speech; categories of dyslalia)

29. A.L. % Articulation Loss (Speech)

30. S.P.A.L. % Articulation Loss with age allowance (Speech)

31. S.P.A.L. categories (Speech)

32. H.L. % (A.M.A.) Percentage hearing loss for speech frequencies in the better ear American Medical Association Audiogram-Average formula

33. Residual Hearing 100 - H.L. % (A.M.A.)

34. Hearing Categories

35. Ear Dominance (Acuity)

Pure Tone Audiometric Test:

36. P.T.A. (W) 125
37. P.T.A. (W) 250
38. P.T.A. (W) 500
39. P.T.A. (W) 1000
40. P.T.A. (W) 2000
41. P.T.A. (W) 4000
42. P.T.A. (W) 8000
43. P.T.A. (B) 125
44. P.T.A. (B) 250
45. P.T.A. (B) 500
46. P.T.A. (B) 1000
47. P.T.A. (B) 2000
48. P.T.A. (B) 4000
49. P.T.A. (B) 8000

50. Aetiological Categories

51. Vision

52. Personal Qualities Rating A. Behaviour

53. Personal Qualities Rating B. Energy

54. Personal Qualities Rating C. Persistence

55. Personal Qualities Rating D. Aggression

56. Personal Qualities Rating E. Dependability

57. Personal Qualities Rating F. Confidence

58. Personal Qualities Rating G. Cooperation

59. Personal Qualities Rating H. Sociability

60. Sex

61. Age

62. O.G. Occupational Grade

Tests 1 to 4 are performance tests of intelligence which require no writing or formal educational accomplishments.

Tests 1 to 8 are the sub-tests of the Snijders-Oomen Non-Verbal Intelligence Scale which is a performance test battery standardised on deaf and hearing children but with instructions clearly designed to avoid the kinds of misunderstanding and ambiguity which arise when deaf children are subjected to intelligence tests (Snijders-Oomen, 1959).

Test 9 is an angled, three-dimensional form board with a device for ejecting the blocks from the board at the end of each trial. Scoring is by counting the number of blocks inserted at each of four trials of 15 seconds each.

Tests 10 to 12 are paper and pencil tests of intelligence.

Test 10 is a timed version of the Progressive Matrices test (Raven, 1961) which uses non-verbal patterns and designs.

Test 11 is a 30 minute test of the ability to interpolate and extrapolate from a linear series of non-verbal geometrical figures.

Test 12 is a test of the ability to abstract from a series which employs numbers, letters and words as symbols in problems which demand intelligence rather than verbal or mathematical skills for their solution.

Tests 13 to 19 are tests of various aspects of language attainment.

Test 13 is a face-to-face test of the ability to recognise spoken sentences without benefit of a hearing aid. The examiner uses a multiple choice technique with photographed material designed to minimise as far as possible the influence of vocabulary, literacy and intelligence.

Test 14. This test is a literal count of the phonemes-in-context produced in two phonemically comprehensive speech samples. Each phoneme in everyday speech occurs at least twice, not in isolation but impacted in the context of speech samples designed to minimise the influence of vocabulary, literacy and intelligence on final scores. Thus this is a test of speech, not simply of articulation, despite the fact that scoring is based upon the accuracy of pronunciation of individual phonemes.

Tests 15 and 16 are part of the Mill Hill Vocabulary Scale which mainly consists of vocabulary for abstract words.

Tests 17 and 18 are tests of picture vocabulary where the subject is asked to write down the name of the objects pictured.

Test 19 is a timed version of Schonell's Visual Word Discrimination Test. The subject is given the correct form of a word and must identify it from among distractors at speed.

Tests 20 to 22 are tests of numerical ability.

Test 20 is a test of the ability to identify given numbers from distractors at speed.

Test 21. This is a simple test of the four elementary operations in mechanical arithmetic. There are 20 number, money and linear measurement sums.

Test 22 is a test of arithmetical-mathematical knowledge which presents varied problems in both non-verbal and verbal media.

Tests 12 and 20 both depend upon perceptual speed rather than formal attainment. In each test a stimulus sheet is clipped upon one side of an H-board and the answer sheet is similarly held on the other. One yard separates stimulus and answer sheets so that a brief retention of the stimulus word or figure is necessary, rather than direct matching, in order to identify it from distractors and to match it on the answer sheet.

Variates 23 to 26 are teachers' estimates of each pupil's ability obtained via head teachers using the appended "Assessment of Linguistic Ability" form. The use of matter-of-fact statements to describe ability levels was chosen to offset the tendency of teachers to apply different standards of assessments. Each rating consists of five statements halved to make ten categories: the statements are reproduced verbatim in APPENDIX B.

Variates 27 to 31 consist of alternative scorings of the information derived from the speech samples used in Test 14.

Test 27 is a word score obtained by adding the number of words pronounced with complete accuracy.

Test 28 is a qualitative assessment of phoneme pronunciation described by Ling (1963) namely:-

(a) normal

(b) simple dyslalia; articulatory error in one zone

(c) multiple dyslalia; articulatory error in two zones

(d) general dyslalia; random articulatory error.

Zones used for classification were labial, alveolar and velar with labio-dentals included in the labial zone and dentals included in the alveolar zone.

Test 29. The number of phonemes pronounced incorrectly in speech samples of Test 14 may be expressed as a percentage of the total number of phonemes in the sample. This percentage, referred to as percentage articulation loss or % A.L. is a useful descriptive summary of intelligibility level and may be easily compared with hearing loss which is conventionally expressed as a negative ability.

Test 30. The percentage articulation loss decreases with age in profoundly deaf school children but an age allowance may be made from existing norms and % A.L. converted by tables to % S.P.A.L. or Standard Predicted Articulation Loss. The % S.P.A.L. value is derived from a scaling procedure which equates the median and quartile points of a given age group's % A.L. scores with the median and quartile points of the % A.L. scores of the 15.6 age group. The % A.L. and % S.P.A.L. are therefore equal for those in the 15.6 age group and % S.P.A.L. for those in younger groups shows the expective % A.L. value at 15.6 that is just before the current school-leaving age.

Test 31. For some purposes a crude intelligible/non-intelligible operational criterion of speech is used and this is obtained by dichotomising % S.P.A.L.

values at the mean thus giving two groups, above mean % S.P.A.L. against below mean % S.P.A.L., which accord very well with the common-sense assessments of intelligibility accorded by teachers' ratings (Montgomery, 1967a).

Variates 32 to 49 are derived from responses to signals from a pure tone audiometer and are various measures and combinations of intensity thresholds in decibels above normal threshold per frequency in cycles per second. Audiometric testing for all but 51 of the survey sample was administered under identical soundproof conditions by the writer using an Amplivox Audiometer Model 61 calibrated to A.M.A. standard and recording the threshold of hearing in decibels above normal threshold at frequencies 125, 250, 500, 1000, 2000, 4000 and 8000 c.p.s. for both ears by air conduction only. In 51 cases the test battery was administered in various localities with acoustic conditions which differed between themselves and from the Edinburgh audiometric testing environment. For these 51 non-Edinburgh based children audiograms were obtained from local audiometric clinics and were used only to calculate broad descriptive measures of residual hearing and not used to investigate the details of residual hearing at specific intensities and frequencies. In general, local audiometric results were only used to define the population under study and not to investigate the particular effects of various types and degrees of deafness. Wherever residual hearing is investigated more directly, the more reliable and uniform audiometric results of the 168 Edinburgh-based children are used.

Variate 32 is the percentage hearing loss for speech frequencies in the better ear. The percentage hearing loss for speech frequencies was calculated for both ears using the conversion tables prepared for the A.M.A. by Fowler and Sabine, Council on Physical Medicine (1947) and currently accepted in Scotland (Scottish Council for Research in Education, 1956). The better ear, according to the percentage value, was established and the percentage value of that ear recorded. The A.M.A. revised method converts pure tone thresholds at 512, 1024, 2048 and 4096 c.p.s. to percentage values which are summed for each ear and combined into a binaural assessment but Variate 32 utilises the responses at 500, 1000, 2000 and 4000 c.p.s. of the better ear only giving a monaural audiogram-average.

Variate 33 is a simple reflection of the % H.L. (A.M.A.) audiogram-average 32, obtained by subtracting the % H.L. (A.M.A.) value from 100.

Variate 34 is another derivative of the % H.L. (A.M.A.) variate which classifies deafness into three categories of hearing loss thus:-

1. 100% H.L. (A.M.A.)
2. 95% to 99.9% H.L. (A.M.A.)
3. below 94.9% H.L. (A.M.A.)

Variate 35 is the description of the dominant ear in terms of acuity as measured by the % H.L. (A.M.A.) calculation in three categories namely, right, left and neither.

Variates 36 to 42 are responses to a pure tone audiometer in decibels above normal threshold for hearing at seven specific frequencies in the worse ear only.

Variates 43 to 49 are responses to a pure tone audiometer in decibels above normal threshold for hearing at seven specific frequencies in the better ear only.

Variate 50 is a classification of the aetiology of deafness according to the school medical record. Five broad groups were identifiable thus:-

Cause of deafness unknown	5
"Hereditary" group with deaf parent(s) or sibling(s)	4
Congenitally deaf	3
Post-meningitis deafness	2
Other causes	1

Variate 51 is a crude assessment of vision into three categories:-

1. wears, or should wear, spectacles now
2. spectacles worn in the past
3. no spectacles prescribed

Variates 52 to 59 are assessments of pupils' personality characteristics derived from a Personal Qualities Rating form (APPENDIX C) which was completed by head teachers in consultation with class teachers. There are eight ratings each on a five point scale.

Variate 52 is a rating of general behaviour

1. Examplary behaviour: a credit to school and parents
2. A well behaved pupil
3. Usually keeps within the rules: conduct average
4. Often troublesome
5. A nuisance in school. Constantly in "trouble": chronic bad behaviour.

Variate 53 is a rating of physical energy

1. Very lethargic: little sign of life if left to own resources. Verging on the comatose.
2. Little energy to spare for work or play.
3. Average energy
4. Energetic
5. Over-active: gives impression of untapped surplus energy. Restless need to "let off steam".

Variate 54 is a rating of persistence

1. At the mercy of almost any distraction, gives up when things get difficult.
2. Needs to be persuaded or tempted (often by extraneous factors) to keep at it.
3. The normal pupil in this respect
4. Persistent: not easily deflected from the job in hand
5. A sticker to an outstanding degree: cannot be shaken from a course of action by difficulties or distractions.

Variate 55 is a rating of aggression

1. Passive and "soft". Afraid to assert own rights. Would "give in" or run away rather than stand firm in a quarrel.
2. Rather slow to assert own rights in any dispute: usually avoids a quarrel.
3. Will stick up for own rights but believes in the motto "Live and let live".
4. Easily induced to join in a quarrel but rarely starts trouble.
5. Aggressive: usually to blame if a quarrel breaks out.

Variate 56 is a rating of dependability

1. Cannot be depended upon, even with supervision and chasing.
2. Needs constant supervision. Little pride in work.
3. Needs external incentives from time to time.
4. Can be depended upon to see things through unchecked by others: has strong inner standards.
5. Goes out of his way to take on more work and responsibility. Completely trustworthy loyal and dependable.

Variate 57 is a rating of confidence

1. Lacks confidence to a marked degree: extremely hesitant and dependent upon others.
2. Hesitant: wary of new people and situations.
3. Average confidence. "Stands on own feet" most of the time.
4. A healthy self-confidence and independence of outlook.
5. Over-confident: usually "leaps before looking".

Variate 58 is a rating of a pupil's attitude to criticism and correction.

1. Resents correction from above.
2. Some reluctance to correct bad work habits and errors.
3. Accepts correction and criticism as "necessary evils" without enthusiasm.
4. Does not mind correction and criticism.
5. Welcomes well-meant criticism and uses it for self-improvement.

Variate 59 is a rating of a pupil's attitude to his schoolfellows.

1. Keeps himself to himself (or herself to herself). Little or no personal relationship with school mates.

2. Not an easy person to fit into a team but does make some attempt to get on with others.
3. Passively accepts group standards of behaviour "Goes along with the crowd".
4. A good team worker, co-operative but happier "in the ranks".
5. A good team worker, co-operative in a group but capable of leadership also.

Variate 60 categorises by sex

Variate 61 is a record of age in years and months

Variate 62 is derived from a follow-up study of the eventual occupation of deaf youths who have left school. Occupational Grade (O.G.) is usually assessed at one year after school-leaving using grades similar to the "Social Class" categories adopted by the 1961 census, thus:-

5. clerical workers
4. skilled craftsmen
3. partly skilled workers
2. unskilled workers
1. unemployed

Test Material

Variates 32 to 49 are derived from responses to a pure tone audiometer. Most testing was undertaken with a model 61 Audiometer by Amplivox Ltd., 80 New Bond Street, London, W.1.

Tests 1 to 22 are standardised cognitive tests of intelligence and attainment.

Tests 1 to 8 are published as the S.O.N. scale by J.B. Wolters, Groningen, Holland.

Tests 9, 11, 12 have been developed at the Applied Psychology Unit, University of Edinburgh.

Tests 10, 15 and 16 are available from Lewis & Co., Gower Street, London, W.C.1.

Test 22 is published by University of London Press Ltd., Warwick Square, London, E.C.4.

Test 19 is reproduced in Diagnostic and Attainment Testing by F. J. and F. E. Schonell, 1956, obtainable from Oliver and Boyd Ltd., Tweeddale Court, Edinburgh, 1.

Tests 13, 14, 17, 18, 20 and 21 have been devised with the particular needs of the profoundly deaf in mind and have been standardised on Grade III deaf children in Scotland. They are available from the writer at the Research Unit, Donaldson's School for the Deaf, Edinburgh, 12.

In the following investigations batteries selected from Tests 1 to 62 were administered to the various sub-samples. Most pupils were tested individually, even with group tests, but occasionally a maximum of four at a time were given group tests by the use of a language laboratory screening arrangement. This segregation was necessary to prevent the rapid exchange of information by signs which is possible between deaf children. Tests were carried out during the period 1963 - 67 in a series of visits to the establishments already listed, save for one session in the local Institute for the Deaf when the school was closed during an outbreak of typhoid.

EXPERIMENTAL RESULTS

Tabulation of the Performance of Sub-samples on Selected Variates*

Group D. Variates 36 to 49 **TABLE 2**

Contingency Table of Audiometric Responses in Both Ears

dBs.	Worse Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	1	0	0	0	0	0	0
30+	4	1	0	0	0	0	0
40+	7	8	1	0	0	0	0
50+	6	3	2	0	0	0	1
60+	14	17	5	2	0	1	0
70+	5	22	14	3	3	6	1
80+	-	5	24	9	14	4	2
90+	-	-	10	21	10	7	-
100	-	-	9	13	9	4	-
No Response	43	25	18	35	46	60	79
Total	80	81	83	83	82	82	83

dBs.	Better Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	4	0	0	0	0	0	0
30+	7	5	1	0	0	0	0
40+	11	10	2	0	0	1	0
50+	8	12	8	1	0	4	1
60+	17	21	8	4	7	3	3
70+	7	14	20	6	6	6	3
80+	-	6	21	19	11	8	1
90+	-	-	15	19	16	10	-
100	-	-	5	12	9	10	-
No Response	27	13	3	22	34	41	74
Total	81	81	83	83	83	83	82

* N.B. in the following tables, the mean value for each cell is followed by the standard deviation value in brackets except where means are derived from cell numbers of less than 5.

TABLE 3

Group D. Variate 32 by variates 36 to 49

Mean and S.D. of % Hearing Loss (A.M.A.) in better ear by Audiometric Categories

	Worse Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	89.0 -	- -	- -	- -	- -	- -	- -
30+	87.4 -	81.1 -	- -	- -	- -	- -	- -
40+	91.2(08.8)	86.2(06.0)	81.1 -	- -	- -	- -	- -
50+	90.2(10.8)	90.0 -	87.4 -	- -	- -	- -	71.2 -
60+	96.3(08.0)	94.6(07.8)	86.3(08.4)	87.8 -	- -	85.8 -	- -
70+	98.8(02.3)	94.7(08.1)	89.9(08.9)	77.8 -	78.3 -	82.3(09.0)	98.4 -
80+	- -	99.7(00.5)	95.5(08.3)	87.9(09.4)	88.2(08.6)	91.7 -	83.0 -
90+	- -	- -	98.6(02.3)	93.4(08.3)	92.1(09.8)	85.3(12.6)	- -
100	- -	- -	99.0(02.2)	99.0(01.9)	98.8(01.1)	96.8 -	- -
No Response	96.5(06.5)	98.4(03.4)	98.6(03.4)	98.3(03.1)	98.4(02.9)	97.9(03.6)	95.6(07.1)

	Better Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	90.2 -	- -	- -	- -	- -	- -	- -
30+	84.3(09.9)	83.7(09.7)	70.2 -	- -	- -	- -	- -
40+	91.8(09.1)	89.7(07.1)	81.5 -	- -	- -	71.2 -	- -
50+	92.5(09.6)	91.7(10.4)	85.1(08.2)	81.1 -	- -	75.1 -	86.5 -
60+	97.6(04.1)	97.0(04.7)	89.6(08.7)	77.9 -	76.2(05.8)	88.6 -	70.7 -
70+	99.0(01.3)	99.3(01.3)	95.8(05.1)	82.2(06.7)	88.3(02.7)	93.5(02.2)	91.5 -
80+	- -	92.4(10.0)	97.6(05.3)	92.9(07.5)	91.6(04.8)	91.1(08.7)	93.5 -
90+	- -	- -	99.4(01.7)	97.6(02.6)	96.5(05.8)	93.1(06.4)	- -
100	- -	- -	100.0(00.0)	99.1(01.9)	98.5(01.9)	98.6(01.9)	- -
No Response	97.7(05.4)	99.5(01.8)	100.0 -	99.7(00.7)	99.7(00.7)	98.7(03.7)	96.5(05.8)

Group D. Variate 30 by variates 36 to 49 TABLE 4

Mean % S.P.A.L. Values for Audiometric Categories

	Worse Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	20.0 -	- -	- -	- -	- -	- -	- -
30+	32.2 -	38.0 -	- -	- -	- -	- -	- -
40+	38.4(19.3)	30.8(15.0)	38.0 -	- -	- -	- -	- -
50+	33.3(11.8)	41.0 -	21.5 -	- -	- -	- -	15.0 -
60+	41.8(19.2)	39.3(12.1)	29.8(13.9)	36.5 -	- -	33.0 -	- -
70+	39.4(10.2)	38.0(18.2)	39.7(18.8)	22.3 -	20.0 -	22.3(09.9)	19.0 -
80+	- -	45.5(18.5)	36.4(12.8)	41.0(21.5)	37.2(19.0)	33.5 -	34.5 -
90+	- -	- -	46.3(16.3)	37.3(15.3)	30.4(12.4)	27.1(14.6)	- -
100	- -	- -	46.5(22.3)	41.5(13.5)	51.1(10.3)	31.7 -	- -
No Response	45.2(20.0)	49.6(21.0)	50.4(21.4)	46.2(20.5)	44.9(18.8)	46.4(17.5)	42.4(18.2)

	Better Ear c.p.s.						
	125	250	500	1000	2000	4000	8000
20+	31.0 -	- -	- -	- -	- -	- -	- -
30+	24.4(08.7)	25.6(07.9)	21.0 -	- -	- -	- -	- -
40+	39.6(14.4)	30.2(10.2)	28.0 -	- -	- -	15.0 -	- -
50+	40.0(18.2)	40.7(19.0)	26.2(10.4)	38.0 -	- -	22.0 -	44.0 -
60+	40.5(17.2)	40.2(11.7)	43.0(21.1)	21.0 -	27.1(22.1)	35.0 -	17.3 -
70+	35.1(18.2)	41.8(18.7)	39.8(13.7)	31.2(14.9)	33.7(12.5)	29.0(12.0)	32.0 -
80+	- -	38.3(23.1)	43.0(16.0)	36.1(17.4)	32.6(14.2)	30.5(17.3)	28.0 -
90+	- -	- -	45.1(20.1)	45.2(16.1)	38.1(13.9)	39.1(13.7)	- -
100	- -	- -	57.2(28.1)	41.9(12.7)	46.8(15.0)	44.8(14.4)	- -
No Response	51.5(19.4)	61.5(18.6)	52.0 -	49.6(21.1)	49.1(18.9)	48.4(18.9)	43.1(18.5)

Group D. Variates 28, 35 and 60 TABLE 5

		Mean and Standard Deviation	
		% S.P.A.L.	% H.L. (A.M.A.)
Q.D.	Simple Dyslalia	17.5 (3.3)	88.0 (12.2)
	Multiple Dyslalia	35.3 (10.5)	93.0 (7.6)
	General Dyslalia	49.8 (16.3)	97.6 (4.4)
Better Ear	Right	39.0 (16.9)	95.5 (7.5)
	Left	41.4 (19.0)	94.0 (8.1)
Sex	Male	46.6 (18.5)	95.8 (6.8)
	Female	31.7 (13.2)	93.6 (9.0)

Group D. Variate 31 to Response/No Response Categories on Variates 36 to 49 TABLE 6

Interrelationship of Dichotomised Speech and Hearing Variates

	Worse Ear			Better Ear		
Stimulus c.p.s.	x^2	Probability	Significance	x^2	Probability	Significance
125	3.281	.067	N.S.	8.011	.005	**
250	5.708	.017	*	8.249	.004	**
500	3.142	.076	N.S.	.4255	.514	4-
1000	1.942	.163	N.S.	7.217	.008	**
2000	.483	.487	N.S.	8.730	.004	**
4000	11.267	.001	**	5.303	.021	*
8000	3.909	.048	4-	4.670	.031	4-

* Significant at .05 level
** Significant at .01 level
N.S. Not significant
4- Expective cell value below 5

Group D. Variates 28, 30 and 43 to 49 TABLE 7

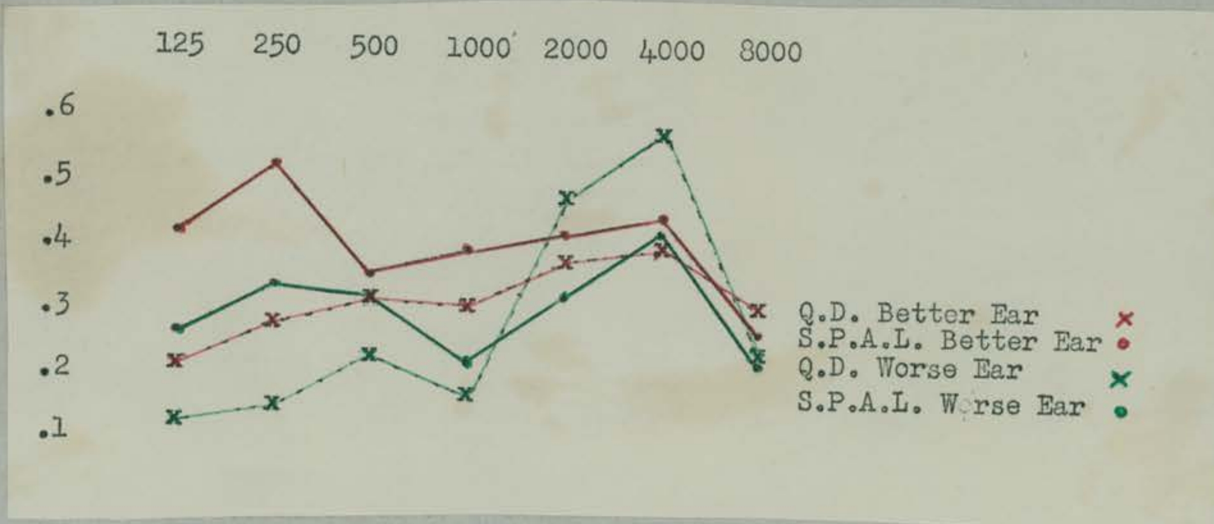
Principal Component Loadings of Speech and Hearing Variates

		Unrotated Factor Loadings						Rotations through % S.P.A.L.		
		I	II	III	IV	V	VI	III^1	III^2	III^3
dBs. loss by c.p.s. in better ear	125	.70	.41	.28	.09	-.27	-.04	.67	.56	.57
	250	.76	.40	.27	.22	-.11	.19	.70	.59	.62
	500	.82	.11	-.09	.23	-.01	.44	.46	.42	.46
	1000	.88	-.19	-.22	.06	-.04	.13	.40	.43	.44
	2000	.75	-.45	-.17	.18	-.09	-.12	.35	.44	.47
	4000	.65	-.60	-.02	.08	-.19	-.26	.42	.55	.55
	8000	.54	-.43	.01	-.00	-.63	.07	.36	.45	.44
Speech	% S.P.A.L.	.55	-.20	.66	.20	.16	-.04	.86	.88	.90
	Q.D.	.48	-.43	.52	.06	.40	.01	.72	.80	.80

Group D. Variates 28, 30 and 36 to 49 FIGURE 1

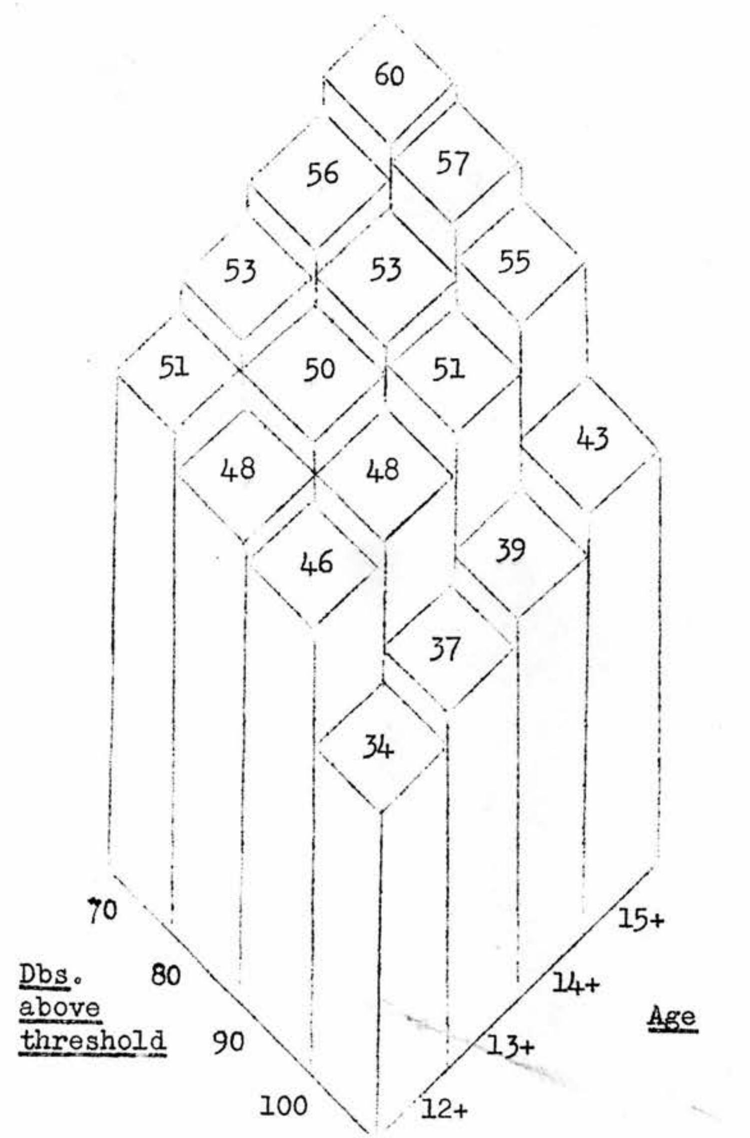
Correlational Profile of Speech Variates

c.p.s.



Group D. Variate 14 by Variates 45 and 61 **FIGURE 2**

Articulation Scores (% Phonemes Correct)
as a Function of Age and Hearing Loss at 500 c.p.s. in Better Ear



Groups A, B and C. Variates 29, 30, 32 and 33 TABLE 8

Speech Development in Relation to Residual Hearing

Age Group	Mean % Hearing Loss	Mean % Articulation Loss	Phoneme Count to Residual Hearing
8+	94.4	59.0	r = .383
12+	95.1	48.0	r = .361
15+	96.1	38.8	r = .530

Group G. Variate 14 TABLE 9

Phoneme Count Scores by Age n = 217

	7+	8+	9+	10+	11+	12+	13+	14+	15+	16+
121 - 125	0	0	0	0	0	0	0	0	2	1
101 - 120	0	0	0	0	3	4	0	0	10	3
81 - 100	0	0	0	2	7	7	0	2	16	2
61 - 80	5	6	7	3	6	13	1	4	12	7
41 - 60	5	8	10	5	5	13	2	1	7	4
21 - 40	0	5	4	5	1	5	0	1	2	0
6 - 20	0	5	3	1	0	2	0	0	0	0

Group E. Test 14 TABLE 10

Order of Difficulty of Phonemes in Given Words and Frequency of Error Substitutes and Omissions

Phoneme	As in	No. Correct out of n = 60	Error Substitutes (Frequency)	Omitted from Intelligible Word
b	blue	54	p (4)	1
b	books	53	p (4)	0
w	one	53	b (2) p (1)	1
w	swing	53	b (1) p (1)	0
p	cup	53	none	0
p	penny	52	b (4)	0
j	yellow	52	none	2
b	bird	49	p (4)	0
au	cow	49	a (1) ɔ (1) h (1)	0
v	five	46	f (1)	8
l	blue	45	none	13
f	five	44	v (12) p (1)	0
é	eight	43	a (3) ɛ (2)	0
d	dog	39	t (5) j (3) ʃ (2) dʒ (1) tʃ (1)	2
au	mouth	38	a (3) o (2) ə (2) ɔ: (1) ɑ: (1) ʌ (1) u (1)	0
n	one	38	d (2) ə (1)	16
r	three	36	d (4) t (1) ɛ (1)	11
ɔi	boy	36	ɔ: (8) ai (1) i (1) ɑ: (1)	0
t	cat	35	n (2) h (1) i (1)	14
f	feather	31	v (4) p (3) k (1) d (1) l (1) b (1)	0
θ	mouth	31	t (6) ð (2) m (1) i (1) a (1) b (1)	6
s	horse	30	t (2) m (1) h (1) n (1) v (1)	15
m	mother	30	b (25) p (4)	0

P.T.O.

Phoneme	As in	No. Correct out of n = 60	Error Substitutes (Frequency)	Omitted from Intelligible Word
g	girl	28	j (7) k (5) d (4) h (3) ʃ (1) a (1) l (1) b (1)	3
k	cow	28	h (7) g (5) j (3) d (3) au (1) p (1)	5
v	knives	27	f (24) b (1)	1
h	hair	27	j (2) k (2) t (1) d (1) p (1) l (1) tʃ (1)	18
j	yellow	27	d (6) n (3) h (3) i (1) p (1) b (1) ŋ (1)	11
s	books	26	ð (2)	28
k	coat	26	g (7) d (4) h (3) w (2) b (1) j (1) ʃ (1) t (1)	6
d	bird	26	t (4) s (1) n (1)	23
r	ring	26	t (2) ʒ (2) d (2) z (1) j (1) s (1) b (1)	1
ai	five	24	a (19) ɑ: (4) e (2) i: (1)	0
ð	mother	22	d (11) m (11) b (5) t (4) θ (1) p (1) l (1)	1
ʃ	shilling	20	d (5) b (1) t (4) tʃ (3) ð (1) j (1) s (1) p (1) w (1)	2
ai	knives	20	a (29) e (2) ɑ: (2) ʌ (1)	2
n	knives	20	d (14) k (7) l (5) h (3) j (2) b (1)	2
ɔi	toys	18	ɔ: (8) ɔ (3) ə (1) au (1)	0
dʒ	bridge	18	ʒ (12) tʃ (1) ʃ (1) n (1) t (1) d (1) b (1) l (1)	7
h	horse	18	tʃ (1) d (1)	37
m	mouth	18	b (31) p (3)	0
ð	feather	17	d (9) l (2) t (2) p (1) θ (1) f (1) i (1)	6
ʃ	shoe	17	t (16) ð (1) j (7) h (3) s (1) tʃ (1) ʒ (1) d (1) l (1)	5

P.T.O.

Phoneme	As in	No. Correct out of n = 60	Error Substitutes (Frequency)	Omitted from Intelligible Word
t	tree	17	d (8) h (7) ʃ (2) j (1) θ (1) s (1) k (1) w (1) b (1)	12
s	swing	16	h (8) t (4) ʃ (4) z (2) b (2) p (1)	11
z or s	knives	16	ð (2) n (1) o (1)	34
θ	three	16	d (16) ð (9) t (8) h (2) r (1) b (1)	2
g	dog	14	k (6)	32
j	yacht	10	b (29) p (5) d (3) k (2) m (2) ʃ (1) ʒ (1) n (1) e (1)	0
ŋ	swing	9	ʃ (1) t (1) a (1)	33
z	zebra	9	d (7) s (4) t (3) k (2) i (1) l (1) tʃ (1) ð (1) j (1) g (1)	4
ŋ	shilling	8	s (2)	29
ʒ	jug	7	j (13) ʃ (8) d (5) b (2) tʃ (1) m (1) s (1) g (1) t (1) r (1) f (1) p (1)	3
dʒ	sledge	7	ʒ (5) ʃ (5) d (3) o (1) z (1) j (1) g (1)	4
dʒ	jug	5	d (8) ʃ (7) j (5) ʒ (2) tʃ (2) b (2) m (1) s (1) g (1) t (1) f (1) p (1)	0
dʒ	bridge	5	ʒ (12) tʃ (1) ʃ (1) n (1) t (1) d (1) l (1) b (1)	7
tʃ	chair	4	ʃ (14) t (10) j (8) p (2) d (2) r (2) dʒ (1) ʒ (1) v (1)	8

Group E. Test 14 TABLE 11

Order of Difficulty of Pronunciation of Phonemes from two Phonemically Comprehensive Speech Samples n = 60

Phoneme	No. Correct	Phoneme	No. Correct	Phoneme	No. Correct	Phoneme	No. Correct
tʃ	5	m	33	t	45	a:	54
dʒ	13	θ	35	ɛ	47	e	54
ŋ	17	s	37	d	49	ʌ	54
z	20	ə:	37	r	49	ə	55
ʒ	24	g	38	v	50	o	56
ʃ	27	k	40	f	51	p	56
ɣ	28	ɔ	40	i	51	w	56
ai	30	ɔi	41	au	51	a	57
j	30	é	43	ɔ:	51	l	58
h	31	n	43	i:	53	u:	58
						b	59

Group E. Test 14 TABLE 12

Order of Preference of Error Substitutes for Consonants n = 60

Phoneme	Frequency of Substitutions	Phoneme	Frequency of Substitutions	Phoneme	Frequency of Substitutions	Phoneme	Frequency of Substitutions
d	119	v	18	r	4	u	1
b	86	m	17	z	4	au	0
t	78	l	17	a	3	ai	0
j	56	ɣ	16	ɛ	3	ɔi	0
ʃ	53	g	16	θ	3	ɔ:	0
h	42	s	13	dʒ	2	ə:	0
p	41	tʃ	12	o	2	a:	0
f	28	n	8	e	1	i:	0
k	26	i	6	ŋ	1	ɔ	0
ʒ	22	w	4	ə	1	é	0
						ʌ	0

Group E. Test 14 TABLE 13

Differential Error Analysis

Phoneme	Speech Ability Groups					
	Bottom	5th	4th	3rd	2nd	Top
tʃ **in chair**	0	0	1	2	1	0
ʃ substituted	0	0	1	1	4	8
j substituted	2	2	1	2	1	0
ʃ **in shoe**	0	1	1	4	4	7
t substituted	2	3	3	5	3	0
j substituted	1	4	1	0	0	0
dʒ **in bridge**	0	0	0	0	3	2
ʒ substituted	0	2	2	2	2	5
ʃ substituted	0	0	1	0	2	1
dʒ **in jug**	0	0	0	1	2	2
d substituted	2	1	3	1	1	0
ʃ substituted	0	0	0	0	4	3
j substituted	0	2	1	1	0	1
θ **in three**	0	1	1	3	2	9
d substituted	3	2	5	3	2	1
ð substituted	0	2	1	3	3	0
t substituted	2	2	2	1	1	0

Group C. Variates 23 to 26 TABLE 14

Distributions of Teachers' Assessments of Linguistic Ability n = 70

Oral Comprehension

	No really useful grasp of what people say: recognises a few simple words only.		Can recognise a few common-place words and phrases when spoken deliberately.		The ordinary deaf child in this respect: average under-standing of the spoken word.		Above average but falls short of understanding at the normal conversational rate.		Can follow a normal conversation reasonably well.	
	1	2	3	4	5	6	7	8	9	10
Boys	0	1	4	4	5	7	3	8	5	0
Girls	0	1	1	4	2	5	5	4	11	0
Total	0	2	5	8	7	12	8	12	16	0

Voice Production

	Cannot produce recognisable words.		Very laboured speech which may be under-stood by those who have taught it.		Can produce speech which is understood by those familiar with it at home and school.		Speech may be occasionally intelligible to others besides family and teachers.		Can produce fairly fluent speech, intelligible to the man-in-the-street.	
	1	2	3	4	5	6	7	8	9	10
Boys	2	1	5	5	5	5	7	6	1	0
Girls	0	1	1	7	3	5	8	5	3	0
Total	2	2	6	12	8	10	15	11	4	0

P.T.O.

Written Composition

	Virtually illiterate: can write a few simple words only.		Can produce many written words and phrases but does not write in sentences.		Many errors of of spelling and grammar but does try to write in sentences if left to own resources.		Writes in simple sentences with occasional grammatical slips.		Can produce good written work in grammatical sentences without assistance.	
	1	2	3	4	5	6	7	8	9	10
Boys	2	3	3	1	4	8	8	4	4	0
Girls	0	0	0	4	3	5	8	7	6	0
Total	2	3	3	5	7	13	16	11	10	0

Manual Communication

	Has no knowledge of fingerspelling.		Has some knowledge of finger alphabet but rarely uses it.		Average competence at understanding fingerspelling.		Can communicate fluently with the adult deaf by using finger alphabet.		Almost total reliance on fingers for means of communication.	
	1	2	3	4	5	6	7	8	9	10
Boys	0	0	1	3	5	2	10	15	1	0
Girls	0	1	3	1	4	3	10	10	1	0
Total	0	1	4	4	9	5	20	25	2	0

Group C3. Variates 23 to 36 TABLE 15

Distribution of Teachers' Assessments for Children with 100% Hearing Loss

	1	2	3	4	5	6	7	8	9	10
23. Oral Comprehension	0	1	2	4	4	3	2	3	3	0
24. Voice Production	2	0	1	8	2	4	3	2	0	0
25. Written Composition	1	1	0	3	4	4	5	1	3	0
26. Manual Communication	0	1	0	3	4	2	5	5	2	0

Group F. Variate 10 TABLE 16

Scores on Progressive Matrices (20 mins.) by Age

Range = 11 - 53 Age 11.0 - 16.2

	11+	12+	13+	14+	15+	16+
50+	0	0	0	0	3	3
40+	0	1	0	0	20	9
30+	1	5	4	5	19	9
20+	1	2	2	0	6	1
10+	2	3	1	2	8	1

Group C2. Variates 3, 4, 5, 6, 7, 10, 11, 12, 14, 15, 16, 17, 26 and 33 — TABLE 17

Correlation Matrix. Concept Study Battery

Mean I.Q. = 102.6 (s.d. 16.7) n = 42

		3	10	11	26	12	15+16	4+5+6+7	14	17	33
S.O.N. Sorting Test	3	1	.64	.54	.48	.44	.37	.33	.24	.23	.01
Progressive Matrices	10		1	.67	.64	.63	.32	.66	.32	.37	.12
A.P.U. Attributes	11			1	.45	.68	.43	.54	.30	.36	-.02
Manual Communication	26				1	.36	.33	.41	.33	.43	-.09
A.P.U. Abstractions	12					1	.54	.59	.39	.55	.00
Mill Hill Vocabulary	15+16						1	.28	.64	.72	.16
S.O.N. "P" Scale I.Q.	4+5+6+7							1	.25	.34	.00
Phoneme Count	14								1	.71	.52
Picture Vocabulary A	17									1	.10
Residual Hearing	33										1

Group B. Variates 9, 11, 13, 14, 17, 18, 21, 33 and 61 — TABLE 18

Correlation Matrix. 11+ Battery

		61	9	11	13	14	17	18	21	33
Age	61	1	.01	.04	-.20	-.23	-.04	-.12	-.10	-.08
3D Formboard	9		1	.48	.36	.36	.30	.34	.54	.01
A.P.U. Attributes	11			1	.17	.24	.29	.25	.57	-.09
Lipreading Test	13				1	.76	.55	.55	.33	.21
Phoneme Count	14					1	.60	.58	.46	.36
Picture Vocabulary A	17						1	.94	.57	-.08
Picture Vocabulary B	18							1	.57	-.07
Four Rules	21								1	-.06
Residual Hearing	33									1

Group B. Variates 9, 11, 13, 14, 17, 18, 21, 33 and 61 TABLE 19

Factor Loadings Matrix. 11+ Battery

		I	II	III	IV	V	VI	VII	VIII	IX
Age	61	-.18	.44	.09	.87	-.03	.04	.09	.00	-.02
3D Formboard	9	.61	.33	.45	-.05	-.43	-.32	-.14	.05	.02
A.P.U. Attributes	11	.51	.55	.41	-.15	.23	.40	-.18	. 00	-.01
Lipreading Test	13	.74	-.40	.01	.09	-.35	.28	.08	-.25	.00
Phoneme Count	14	.80	-.42	.12	.08	-.02	.14	.17	.32	-.02
Picture Vocabulary A	17	.85	.03	-.42	.18	.14	-.04	-.13	.02	.15
Picture Vocabulary B	18	.85	.00	-.42	.10	.10	-.14	-.18	-.03	-.14
Four Rules	21	.76	.35	.12	-.16	.24	-.20	.37	-.11	-.00
Residual Hearing	33	.09	-.67	.58	.24	.32	-.17	-.12	-.09	.01
Percentage Taken Out		43.36	16.79	12.33	10.24	6.21	5.07	3.33	2.15	0.51

Group C. Variates 4 to 26 and 33 TABLE 20

Correlation Matrix: 15+ Battery

	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	33
4 SON Block Design	1	.35	.55	.65	.33	.34	.67	.54	.57	.27	.17	.29	.15	.22	.26	.27	.37	.57	.60	.26	.24	.29	.09	$\overline{.13}$
5 SON Picture Memory		1	.42	.29	.27	.20	.25	.16	.27	.12	.13	.12	.05	.11	$\overline{.03}$	$\overline{.02}$	.24	.24	.27	.17	.20	.09	.06	.22
6 SON Picture Series			1	.56	.40	.22	.65	.51	.53	.34	.27	.39	.16	.33	.26	.37	.40	.44	.57	.30	.31	.38	.08	$\overline{.02}$
7 SON Figure Analogies				1	.45	.45	.74	.69	.67	.38	.30	.40	.17	.30	.32	.42	.50	.56	.64	.22	.29	.38	.30	.01
8 SON Knox Cubes					1	.19	.39	.43	.40	.33	.21	.18	.06	.02	.07	.15	.28	.36	.41	.25	.11	.20	.19	.04
9 McComisky 3D Form Board						1	.36	.26	.33	.21	$\overline{.01}$	.15	.09	.06	.07	.31	.45	.21	.26	.12	$\overline{.02}$	.11	.19	$\overline{.02}$
10 Matrices 1938							1	.68	.67	.42	.35	.45	.17	.33	.35	.44	.51	.61	.72	.28	.28	.38	.34	.07
11 APU Attributes								1	.66	.44	.42	.42	.32	.34	.36	.44	.49	.58	.61	.42	.35	.38	.09	.05
12 APU Abstractions									1	.63	.48	.61	.48	.56	.61	.56	.56	.70	.78	.34	.28	.47	.26	$\overline{.04}$
13 Lipreading Test										1	.75	.75	.57	.77	.84	.80	.71	.46	.72	.75	.74	.85	.34	.08
14 Phoneme Count (Speech)											1	.74	.49	.69	.68	.55	.49	.56	.59	.57	.80	.69	.25	.53
15 Mill Hill Vocabulary A												1	.51	.78	.76	.73	.58	.52	.72	.39	.48	.66	.36	.10
16 Mill Hill Vocabulary B													1	.60	.61	.52	.35	.29	.45	.35	.40	.49	.15	.03
17 Picture Vocabulary A														1	.91	.79	.48	.45	.61	.42	.49	.67	.36	.07
18 Picture Vocabulary B															1	.83	.50	.49	.67	.49	.50	.68	.40	.03
19 Visual Word Discrimination																1	.68	.44	.68	.46	.47	.69	.40	$\overline{.06}$
20 Number Perception																	1	.52	.64	.56	.41	.52	.35	.07
21 Four Rules (Arithmetic)																		1	.81	.39	.35	.51	.19	.02
22 Vernon Maths																			1	.45	.44	.62	.29	$\overline{.02}$
23 Oral Comprehension																				1	.63	.60	.17	.10
24 Voice Production																					1	.67	.10	.36
25 Written Composition																						1	.19	.06
26 Manual Communication																							1	.02
33 Residual Hearing																								1

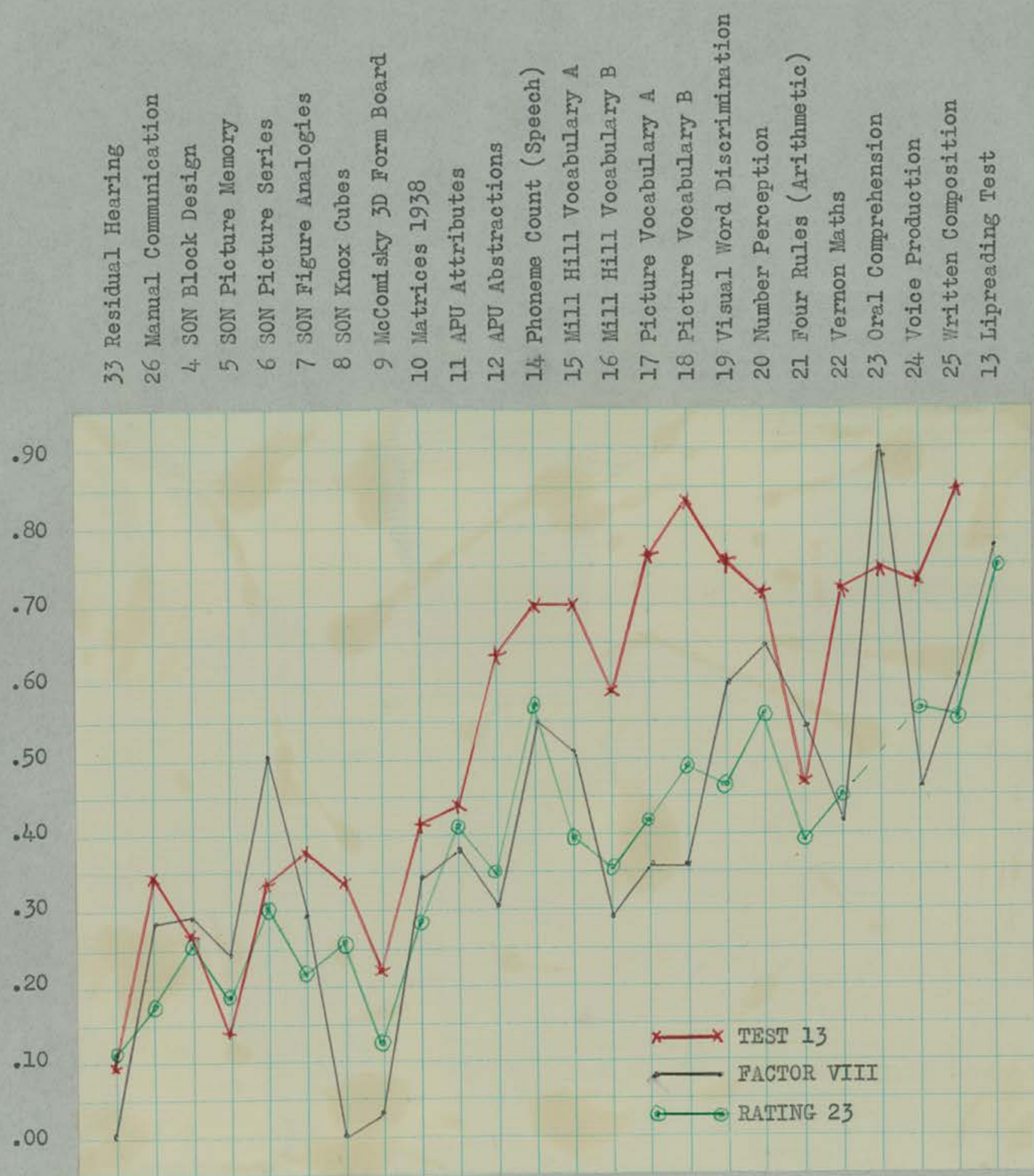
Group C. Variates 4 to 26 and 33 TABLE 21

Orthogonal Factors Derived from Graphical Rotation of Principal Components

		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	h^2
Tests	4 SON Block Design	.14	$.\overline{07}$	$.\overline{14}$	.09	$.\overline{21}$	.42	.30	.29	.29	.63	.06	1.08
	5 SON Picture Memory	.26	.26	.03	.30	.27	.68	.29	.24	$.\overline{17}$	.04	$.\overline{14}$	1.04
	6 SON Picture Series	.00	.33	$.\overline{13}$	.15	$.\overline{02}$	.48	$.\overline{05}$	.50	.47	.23	$.\overline{09}$	1.03
	7 SON Figure Analogies	.02	.13	.05	$.\overline{02}$	.06	.18	.24	.27	.42	.63	.00	0.89
	8 SON Knox Cubes	.14	.81	.01	$.\overline{12}$	.01	$.\overline{02}$	$.\overline{04}$	.00	.00	.56	$.\overline{14}$	1.06
	9 McComisky 3D Form Board	.00	.00	.07	.86	$.\overline{05}$	.00	.00	.03	.00	.45	$.\overline{04}$	1.02
	10 Matrices 1938	.02	$.\overline{04}$	.15	.06	.10	.33	$.\overline{07}$	.33	.48	.65	.12	1.06
	11 APU Attributes	.30	.06	$.\overline{16}$	$.\overline{07}$	.12	.11	.20	.38	.26	.67	.36	1.11
	12 APU Abstractions	.28	.16	.05	.10	$.\overline{04}$	.26	$.\overline{08}$	.30	.11	.52	.56	1.04
	13 Lipreading Test	.18	.15	.12	.18	.07	$.\overline{20}$	.04	.78	.16	.08	.43	1.02
	14 Phoneme Count (Speech)	.21	.08	$.\overline{02}$	$.\overline{06}$	.50	$.\overline{01}$	.01	.55	.20	.22	.36	0.96
	15 Mill Hill Vocabulary A	.15	.08	.24	.10	.09	.10	$.\overline{12}$	.51	.24	.07	.64	1.04
	16 Mill Hill Vocabulary B	.08	.10	$.\overline{16}$	$.\overline{05}$	$.\overline{01}$	.14	$.\overline{09}$	.29	$.\overline{37}$	.22	.69	0.89
	17 Picture Vocabulary A	.04	.00	.32	.01	.06	.11	.00	.36	.17	$.\overline{04}$	.74	0.92
	18 Picture Vocabulary B	.04	.00	.33	.02	.00	$.\overline{06}$	.00	.36	.18	$.\overline{03}$	.73	0.89
	19 Visual Word Discrimination	.04	.01	.26	.28	$.\overline{08}$	$.\overline{08}$	$.\overline{15}$	.60	.30	.10	.57	1.07
	20 Number Perception	.36	$.\overline{05}$	.14	.42	.17	.00	$.\overline{29}$	.65	.29	.28	.18	1.18
	21 Four Rules (Arithmetic)	.47	$.\overline{11}$	.01	.17	.23	$.\overline{29}$	.10	.54	$.\overline{02}$	.00	.24	0.84
	22 Vernon Maths	.35	.11	.04	.04	$.\overline{03}$	.22	.00	.42	.30	.40	.41	0.89
Ratings	23 Oral Comprehension	.27	$.\overline{08}$	$.\overline{11}$	.06	.11	$.\overline{22}$	.03	.90	.00	.13	$.\overline{02}$	1.07
	24 Voice Production	.20	$.\overline{11}$	.00	$.\overline{05}$	.39	$.\overline{10}$	.22	.46	.16	.06	.54	0.96
	25 Written Composition	.11	.15	$.\overline{05}$	.10	.04	$.\overline{21}$	.23	.61	.32	.01	.48	0.99
	26 Manual Communication	$.\overline{01}$	$.\overline{02}$	.89	$.\overline{01}$	.05	$.\overline{03}$	$.\overline{02}$	.27	.01	.26	.00	1.00
	33 Residual Hearing	.00	.00	.00	.00	.97	.00	.00	.00	.00	.00	.00	1.11

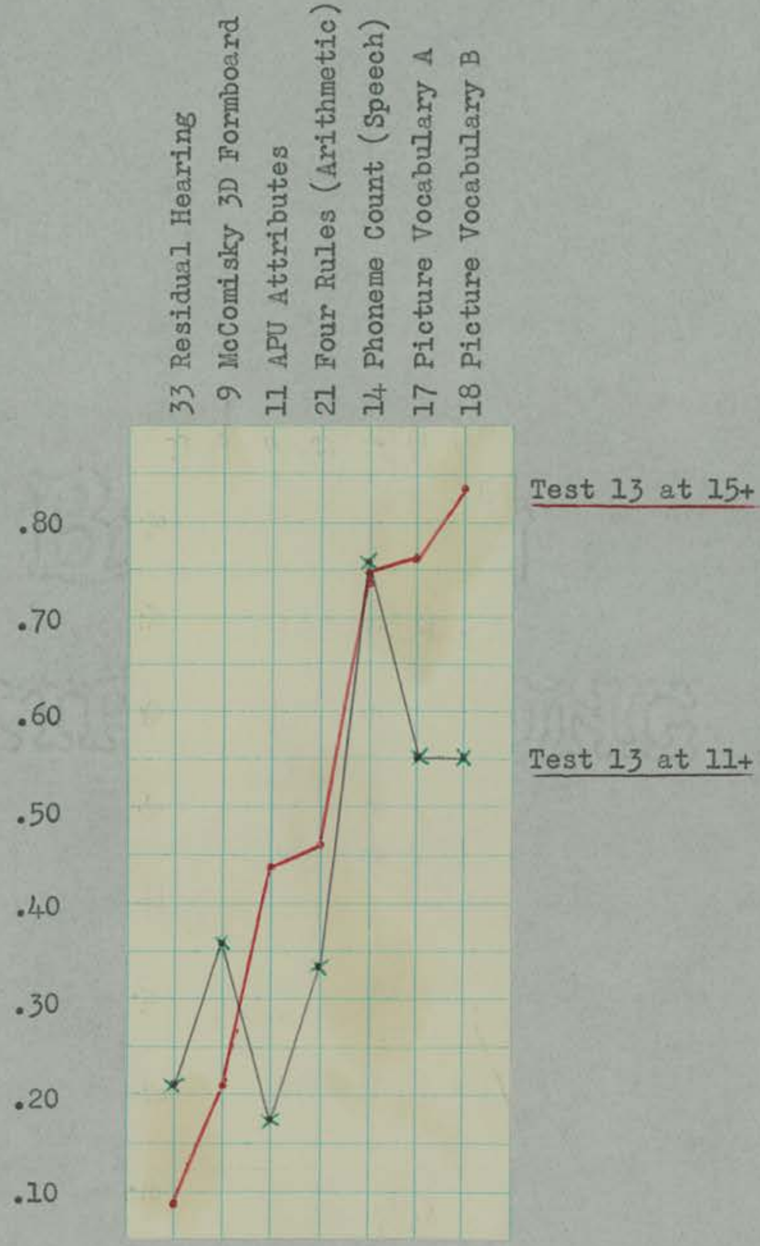
Group C. Variates 4 to 26 and 33 FIGURE 3

Correlational and Factorial Loading Profiles of Lipreading Abilities at 15+



Groups B and C. Variates 4 to 26 and 33 FIGURE 4

Comparative Correlational Profiles of Lipreading Test 13 at 11+ and 15+



Group C. Variates 13, 23, 19, 20 and 51 TABLE 22

Contingency Table showing the Relationship of Vision to Lip-Reading and Perceptual Speed at 15+

	Oral Comprehension									Donaldson Lipreading Test							
	2	3	4	5	6	7	8	9	Tot.	5-9	10-14	15-19	20-24	25-29	30-34	35-40	Total
No Spectacles	1	3	3	3	9	5	10	11	45	0	2	3	7	9	16	8	45
Spectacles in Past	0	0	1	1	1	0	2	2	7	0	0	0	4	1	11	1	7
Spectacles Now	1	1	4	3	1	2	0	2	14	1	0	1	5	2	3	2	14

	Visual Word Discrimination							Number Perception						
	5+	10+	15+	20+	25+	30+	Tot.	5+	10+	15+	20+	25+	30+	Total
No Spectacles	4	7	11	10	13	0	45	0	3	10	18	10	4	45
Spectacles in Past	0	0	3	3	1	0	7	0	0	1	3	3	0	7
Spectacles Now	0	6	2	3	3	0	14	2	1	1	7	2	1	14

Group C. Variates 10, 17, 30, 32, 50 and 61 TABLE 23

Means (and Standard Deviations) of Intelligence, Vocabulary, Speech and Hearing Variates by Aetiological Categories at 15+

	Unknown	Hereditary	Congenital	Meningitis	Other	All Groups
Numbers	12	10	21	16	7	66
Percent	18.18	15.15	31.82	24.24	10.61	100
Age	15.11 (2.0)	15.11 (1.7)	15.11 (2.3)	15.10 (1.4)	15.11 (1.6)	15.11 (1.9)
Raven's Matrices 10	40.42 (7.95)	41.30 (8.33)	38.62 (9.36)	33.56(11.56)	38.85 (4.48)	38.15 (9.36)
Picture Vocabulary 17	18.67 (5.05)	17.80 (5.57)	18.09 (3.83)	15.19 (4.64)	15.86 (2.19)	17.21 (4.52)
S.P.A.L. % 30	33.0 (16.0)	48.2 (20.4)	34.0 (13.2)	44.0 (18.0)	31.5 (12.4)	38.8 (17.0)
H.L. % (A.M.A.) 32	97.7 (3.01)	99.1 (0.12)	93.9 (8.37)	96.4 (7.38)	93.6 (8.07)	96.1 (6.83)

Group C. Variates 52 to 59 TABLE 24

Distribution of Personal Qualities Ratings at 15+ (APPENDIX C)

	1	2	3	4	5	Total
52 Behaviour	13	12	32	8	1	66
53 Energy	0	12	40	14	0	66
54 Persistence	3	16	26	19	2	66
55 Aggression	1	14	40	4	7	66
56 Dependability	1	10	29	16	10	66
57 Confidence	1	13	30	21	1	66
58 Cooperation	2	12	19	28	5	66
59 Sociability	1	9	24	11	21	66

Group C. Variates 52 to 59 and 14 TABLE 25

Mean Phoneme Count (Speech) Scores (and Standard Deviations) by Personal Qualities Categories (APPENDIX C)

	1	2	3	4	5	Total
52 Behaviour	94.69(15.15)	86.75(18.53)	77.06(23.82)	70.37(26.09)	67.00	81.40(22.61)
53 Energy	-	66.45(19.56)	82.80(23.29)	89.14(18.31)	-	81.40(22.61)
54 Persistence	82.00	63.20(19.29)	86.62(18.93)	86.32(21.93)	102.50	81.40(22.61)
55 Aggression	67.00	75.50(24.81)	85.23(19.44)	85.75	71.43(26.83)	81.40(22.61)
56 Dependability	67.00	67.00(27.59)	78.32(22.38)	91.25(19.52)	90.10(14.02)	81.40(22.61)
57 Confidence	63.00	71.38(23.57)	79.93(22.86)	91.76(18.38)	55.00	81.40(22.61)
58 Cooperation	86.50	70.08(21.77)	83.67(22.90)	81.00(23.45)	100.60 (7.20)	81.40(22.61)
59 Sociability	100.00	80.33(28.94)	78.17(22.92)	76.73(25.46)	86.95(18.01)	81.40(22.61)

Group C. Variates 50, 52 and 55 TABLE 26

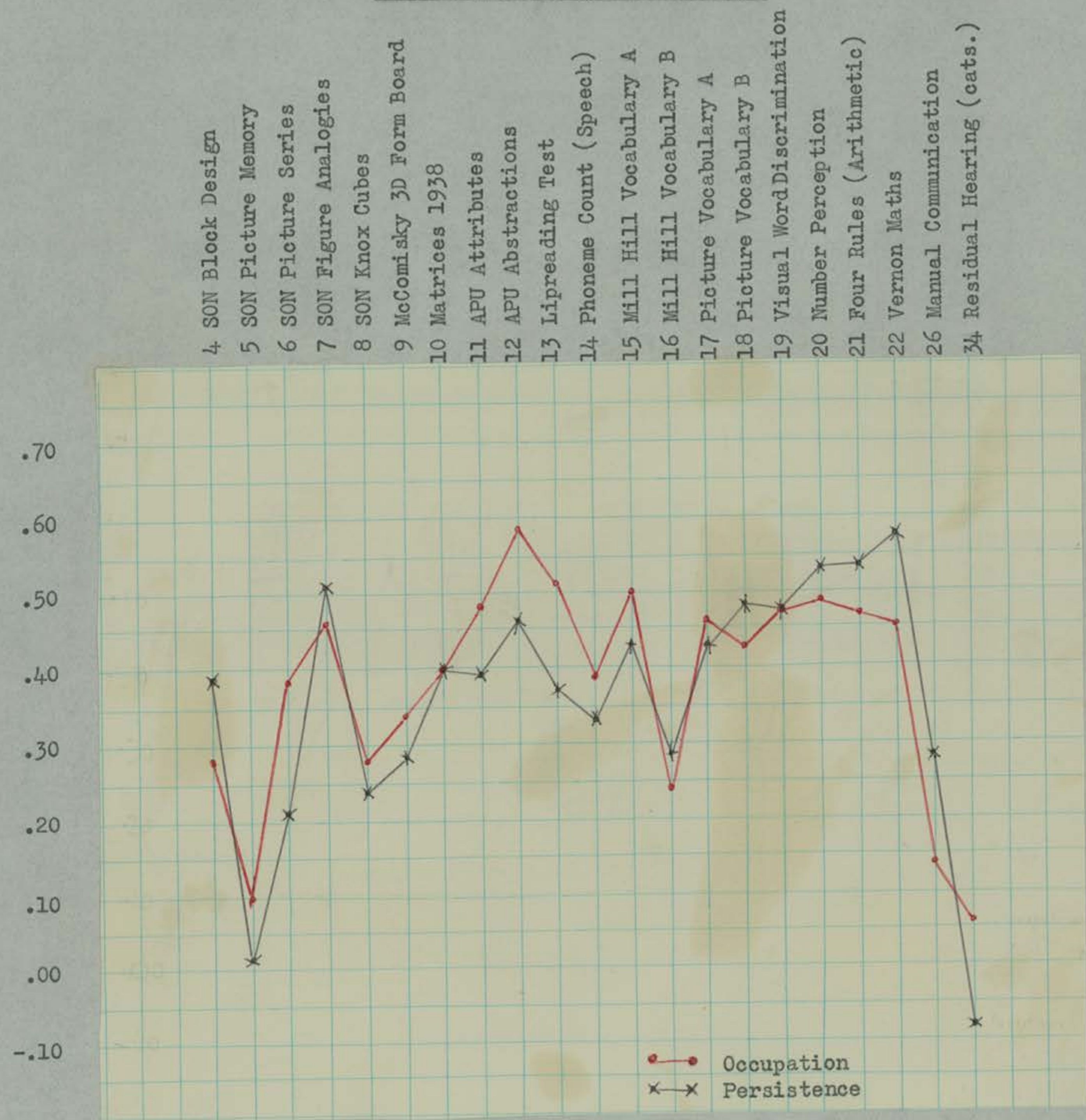
Behaviour and Aggression Ratings by Aetiological Categories

Aetiology	Behaviour					
	1 %	2 %	3 %	4 %	5 %	Total %
Unknown	33.3	16.7	41.7	8.3	-	100
Hereditary	10.0	20.0	60.0	10.0	-	100
Congenital	28.6	23.8	38.1	4.8	4.8	100
Meningitis	12.5	6.2	56.2	25.0	-	100
Others	-	28.6	57.1	14.3	-	100

Aetiology	Aggression					
	1 %	2 %	3 %	4 %	5 %	Total %
Unknown	-	8.3	66.7	8.3	16.7	100
Hereditary	-	20.0	60.0	10.0	10.0	100
Congenital	4.8	19.0	66.0	-	9.5	100
Meningitis	-	31.25	43.7	6.2	18.7	100
Others	-	42.8	42.8	14.3	-	100

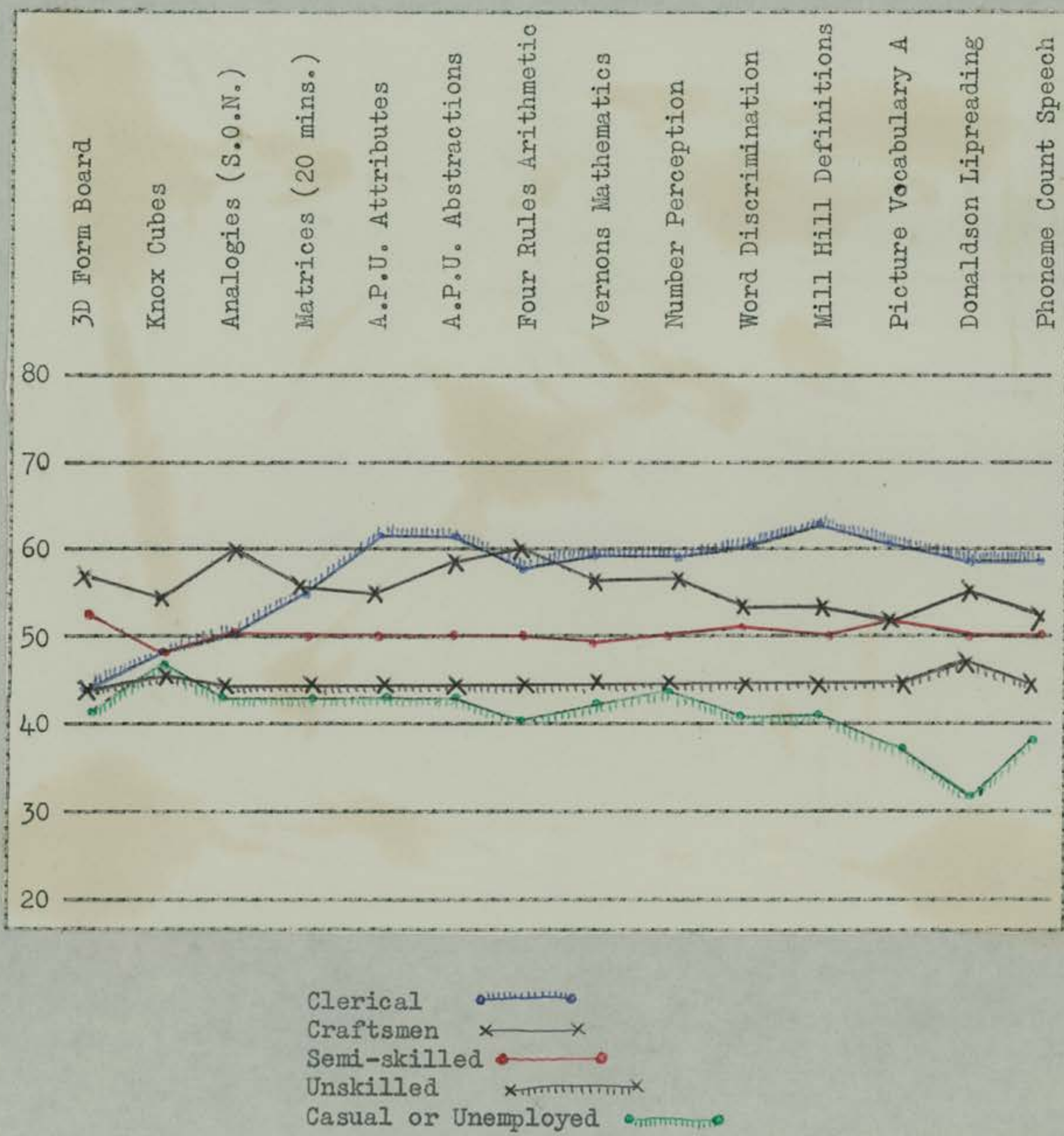
Group C. Variates 4 to 22, 26, 34, 54 and 62 **FIGURE 5**

Comparison of Correlational Profiles of Persistence Rating at 15+ and Eventual Occupational Grade



Group C. Variates 7 to 15, 17, 19 to 22 and 62 **FIGURE 6**

Vocational Guidance Battery Profiles of Five General Occupational Grades



THE INTERACTION OF ABILITIES

With some exceptions, the studies of the groups comprising the present survey have been concerned with the interaction of separable abilities of the profoundly deaf in so far as these may be implied from the interaction of the given variates. TABLES 4, 5, 6, 8, 9, 16, 22, 23, 25 and 26 and FIGURES 2, 6, 8 and 9 each show to varying degrees the interaction of some of the variates under study. A wider view of interaction relationships is evident in the correlation profiles of FIGURES 1, 3, 4 and 5 and, more especially, in the correlation and factor matrices of TABLES 7 and 17 to 21.

In the later discussion of communication attainments and cognitive capacity the main abilities are described, in their own right, as separable entities. Under these separable ability headings interrelationships are discussed and particular interaction effects indicated. But at this stage the total interaction is brought under scrutiny to outline the picture at the "strategical" level before engaging in tactical exercises at closer quarters later.

Some broader views of multivariate interaction are evident in the 11+ factorial study of Group B (TABLES 18 and 19) and in the analysis of speech and hearing variates (TABLE 7) in Group D. The main study which shows more than any other the overall interaction of abilities is the factorial analysis of the performance of Group C on the 15+ test battery. This battery evaluates the performance of pupils at the end of their school career and is a more valid reflection of educational processes, in most respects, than similar assessments of those who have yet to complete their education.

Previous Work In a previous attempt to assess the role of communication skills in the education of the profoundly deaf (Montgomery, 1966b) it became obvious that the influence of residual hearing, intelligence and written language was considerable and that some partialling technique would be necessary. In consequence, a test battery suitable for factorial analysis was assembled with a substantial number of overlapping tests in order that factors may be identified more easily and that test results may be amply confirmed to offset the occasional unreliability of single tests which has been thought to occur in psychometric assessment of the deaf (Murphy in Ewing, 1957).

The word "factor" often appears in titles of studies attempting to identify various concomitants of deafness (O'Neill and Davidson, 1956; Simmons, 1959; Kent, 1963; Evans, 1965; Franks, 1966) but no previous factorial analysis of the cognitive abilities of the profoundly deaf is known to the present writer. The nearest precedent to the present work is the unpublished work of Farrant[1], quoted by Myklebust (1960) which employed factorial analysis in a comparative study of a hearing sample against a sample of deaf and partially deaf subjects. Presumably because standardised tests for the deaf must be administered individually, or in small groups of four at most, the majority of researchers have been content to register performance on a few tests. This invariably results in some factors being uncontrolled and quite often the population defining residual hearing variate has been left uncontrolled (Oléron, 1950; Simmons, 1959; Evans, 1965; Askew, 1965.)

Procedure

Tests were administered during the years 1963 to 1966 at the time of school-leaving usually in a pupil's last term at school. Most pupils were tested individually, even with group tests, but occasionally a maximum of four at a time were given a group test by the use of the language laboratory screening arrangement already described.

1 A summarised version was published see Farrant (1964).

Teachers' estimates were made independently and added to the battery to serve as validation criteria for the standardised tests and as corroborative aids to the identification of factors. All variates save the sex, age and aetiological categories were correlated to all others and the resultant product moment correlation coefficients assembled in the correlation matrix shown at TABLE 20. The correlation matrix was then submitted to a principal components analysis giving a general factor and 23 bipolar factors. Inspection showed clearly that the bipolar pattern is an inappropriate description of cognitive abilities which are more meaningfully adapted to a factor pattern which accords to the criteria of positive manifold and simple structure. To meet this need for more psychologically meaningful factors a series of graphical rotations was undertaken and the process halted at the solution shown in TABLE 21. This solution clearly distinguishes identifiable factors which make good psychological sense. This solution is not, of course, mathematically unique and further rotation to increase positive manifold and improve the factor structure was considered. But the communality value for each variate indicated that the approximations of succeeding rotations were accumulating and that further rotation would lead to solutions which, however psychologically elegant, would be unacceptably approximate.

Results

The main findings of this analysis are set out in TABLES 20 and 21. Because, as has been noted, the factor solution given in TABLE 21 is not unique the complete correlation matrix is reproduced in TABLE 20 to enable alternative rotated factor solutions to be computed if desired.

Inspection of the correlation matrix shows that no significant negative correlations obtain. It is of interest, however, that the slight negative relationship between the Block Design Test 4 and residual hearing which is significant when deaf and hearing populations are compared is still observable in the present population which is highly selected on the residual hearing variate.

The principal components analysis derived from the correlation matrix yielded a general factor and 23 bipolar factors. As they stand, these are psychologically meaningless configurations and have not been reproduced here. Instead a rotated solution is presented in TABLE 21 where it may be noted:-

Factor I is positively loaded on the three numerical tests.

Factor II shows a relatively specific loading on the memory test 8.

Factor III has a high loading on the rating of Manual Communication and some slight positive loading on the Mill Hill Vocabulary A (Definitions) Test 15 and on both Picture Vocabulary Tests 17 and 18.

Factor IV has a high relatively specific loading on the McComisky Test 9 with positive loadings on tests with a visual perception component 5, 19 and 20.

Factor V has a high loading on the residual hearing test and substantial loadings on speech variates 14 and 24.

Factor VI is a bipolar factor contrasting Tests 5, 6 and 4 with attainment tests.

Factor VII is not easily identifiable as a meaningful factor but it has negative loadings on the two tests of perceptual speed 19 and 20.

Factor VIII has high loadings on the two Lip-Reading Variates 13 and 23. The relatively high loadings on other verbal and numerical tests probably indicate the importance of good general attainment for the development of ability in Lip-Reading.

Factor IX contrasts tests 6 and 16 and is not easily identifiable.

Factor X has high loadings on the intelligence tests and may be assumed to be a factor of non-verbal reasoning. The importance of this factor in the mathematics test 22 may be noted.

Factor XI has high loadings on written vocabulary tests 15, 16, 17 and 18. The verbal content of part of mathematics test 22 accounts for its relatively high loading with this factor. Speech tests 14 and 24 and Lip-Reading Test 13 obviously have a vocabulary component which accounts for their relatively high loading on this factor as has, less obviously, intelligence test 12 which uses a few words in some test items.

From the relationships set out in the correlation and factor matrices it is possible to trace the interaction of many test variates and factors. At this point it is proposed to examine the most important of the abilities under study and to deploy them for the purposes of description under the separable headings of the following chapter.

DESCRIPTION OF ABILITIES

To separate the abilities described below from the complex interaction described in the previous chapter is to some extent to falsify the picture. Again, much reference to previous investigators, who have not always taken a broad multivariate approach, introduces the kind of limited description of abilities from which this study has sought to escape. By frequent reference to the results of the factorial analysis already presented, however, the functional interaction of all abilities examined will not be lost in the anatomical exercise which follows.

The dissection of abilities takes the course outlined here:-

Communication Attainments:	Residual Hearing
	Speech
	Lipreading
	Manual Communication
	Written Language
Other Abilities:	Numerical Ability
	Perceptual Speed
	Intelligence

Residual Hearing

Total deafness is extremely rare and even within the profoundly deaf population residual hearing exists at the higher intensities above normal threshold for hearing. The early work of Kerr Love (Love, 1911) emphasised the value of residual hearing to deaf children and the techniques of using this important communication avenue for speech reception and production with the aid of the powerful auditory amplification devices which are now standard classroom equipment in schools for the deaf are lucidly explained in a recent commentary on education of the deaf by Watson (1967).

None of the present survey sample failed totally to respond to the signals of a pure-tone audiometer although the majority were too deaf to give valid response to speech audiometry. The most reliable sample for the purposes of studying residual hearing is Group D, comprising 83 Edinburgh-based children drawn from all parts of Scotland and, as TABLE 1 indicates, typical of the profoundly deaf population as a whole. The actual pure-tone responses of Group D as a whole are given in TABLE 2, which in effect is a group audiogram for profoundly deaf school children aged 10 to 16 years. Oddly enough, this kind of group audiogram does not feature in the literature concerned with the remedial educational treatment of deafness, despite its obvious relevance to those concerned with auditory training and the design of amplification devices. The latter persons often tend to respond more readily to the lesser needs of less deaf children simply because the immediate returns are more obvious and the techniques may be seen to be effective. The group audiogram of TABLE 2 yields descriptive data which may also be useful to those concerned with the design and calibration of devices which transpose high frequency speech input into equivalent patterns at lower frequencies where residual hearing more commonly exists (Pimonow, 1962).

The relationship of residual hearing for pure tones to speech development in the profoundly deaf has been examined in some detail by the present writer (Montgomery, 1967a) in order that relationships between specific hearing losses at particular frequencies and intensity levels and qualitative measures of articulation loss may be established. The results of this investigation are given in TABLES 2 to 7 and FIGURES 1 and 2 and establish many general and specific relationships between speech and hearing within the profoundly deaf population. In the main this investigation has been concerned with the establishment of an audiogram-average method to summarise the data from the pure-tone audiogram for clinical purposes and consequently discussion of it is more appropriately reserved until the later chapter (p.128) which deals with the clinical applications of research findings.

The developmental aspect of the relationship between speech and hearing is set out in TABLE 8 which shows a closer correlation of hearing loss and articulation loss at 15+ age level than at 8+ and 11+. At each age level, however, the relationship is well above the values required for statistical significance.

The factor analytical study of Group C confirms the importance of residual hearing in the speech attainments of the older deaf children and incidentally lends support to the current classification procedure which defines deafness by a grading system based on the interaction of speech and hearing and not solely on residual hearing for pure tones. The correlation matrix of TABLE 20 reveals no significant relationship of hearing with any intelligence, attainment or communication variates save the two speech variates (r = .53 and .36). Thus within this population with a narrow range of hearing loss, speech is still dependent to a substantial degree upon the possession of residual hearing. In the factor solution of TABLE 21 the relatively specific residual hearing factor with positive loadings on the speech variates has been taken out so that its influence upon other inter-relationships has been removed.

Speech

It is the hall-mark of sound professionalism to restrict activities well within the limits of professional competence. On this score, teachers of the deaf in Scotland are realistically professional about the extent to which profoundly deaf children may be trained to produce intelligible speech. The teachers' estimates of seventy school-leavers are given in TABLE 14 clearly reflecting the professional view that the majority of children rated do not produce speech which may be even occasionally intelligible to those unfamiliar with it and that a mere 4 out of 70 are able to produce "fairly fluent speech, intelligible to the man-in-the-street" after some twelve or more years in schools officially committed to teaching by the "oral method" to the exclusion of all other methods. Elsewhere, claims about the effectiveness of speech training are not so conservative and it is common enough to come across qualitative statements such as "children with 100 per cent hearing loss may be taught to speak fluently" which somehow omit to mention that it is only a small proportion of such children who succeed orally. Inspiring as it is in literature, the Helen Keller tradition is often misleading as a guide to the profoundly deaf pupil of average ability who rarely acquires a personal tutor.

In the present writer's view the process of learning to speak is, for a deaf child, roughly comparable in difficulty to the task for a hearing child of learning to play one of the more acoustically uncertain orchestral instruments such as a violin or French horn which do not depend on a keyboard or fixed fingering arrangement. The fact that some hearing children manage this accomplishment is rarely advanced as an argument for the view that all should. Similarly, the fact that some children eventually take honours degrees at University is not often accepted as evidence that all children are able to do this. But many educators employ the same appalling logic in defence of the thesis that all deaf children should be taught speech: "Some are able to speak fluently therefore all should be able to speak fluently".

Given that there is no organically based dysfunction of the speech articulators in most deaf children (Taylor, 1967) the main inhibition upon speech development is the lack of auditory feed-back from the speaker's own voice. Deaf speakers have difficulty in monitoring their own voice without the assistance of auditory amplification (Whetnall, 1956; Pimonow, 1962; Watson, 1967), visible speech devices (Coyne, 1938; Sterne, 1939; Cherry, 1957; Plant, 1960; Miller and Montgomery, 1966) or the aid of a devoted tutor who is prepared to act as the aural equivalent of the guide dog for the blind.

A recurring finding in investigations of language abilities in deaf children is that girls are better scorers than boys. Myklebust (1960) found some 60 per cent of deaf boys to be rated by their teachers in the bottom categories of "Fair" and "Poor" speakers while only 47 per cent of deaf girls were so rated. The sex difference in the present study (TABLE 14) is obviously in the same direction but, unlike Myklebust's study, this difference falls short of statistical significance. Apart from any innate differences in language acquisition between the sexes such differences as exist may be due to the fact that girls are more often taught by female teachers who are more orthodox and conformist in their belief in the oral method and more likely to teach speech at the expense of other subjects than male teachers. The deaf girls themselves, in common with their hearing counterparts, are more educationally conformist in their attitude than boys who are much more likely to question their educational diet, particularly when it appears to be indigestible. Finally, the earlier physical maturity of girls may promote more responsible attitudes to school-work resulting in more effective attainment in girls. In a school for the deaf attainment mainly means language attainment and improvement in general language attainments may transfer positively to speech improvement. A similar effect is found among hearing candidates for the 11+ examination where the Moray House Verbal Reasoning tests often show a sex difference favouring girls and, as this difference is not maintained later, a correction is made for the purpose of selection.

The Phoneme Count

The main instrument used in the present study for the exploration of speech ability in the deaf is not the teachers' rating but a statistically standardised test, the Phoneme Count, which is described in a previous section as Test 14. This is mainly a test of the ability to produce phonemes-in-context and as such it may be regarded as a speech test not merely as a test of articulation, despite the fact that scoring is based upon the accuracy of articulation. The quantum of speech measured could have been a phone, phoneme, morpheme, logatome or larger linguistic units but the phoneme is to be preferred in that it gives optimal transfer in the articulatory approach to training and hence is the most effective operational criterion of speech ability.

The phoneme is largely a unit of perceptible differences in speech and the problem of selection of appropriate linguistic units for speech perception studies has been discussed by Fay (1966) who reviews the literature of previous essays in the quantising of speech. In many ways, the discussion is reminiscent of the physicists celebrated controversy as to whether energy is more accurately described as existing in particles or waves. In practice, however, some experiments based on particle theory yielded useful results and equally useful and valid results were also obtained from experiments accepting wave theory. In the present study there is little conflict between the concept of language as a series of discrete entities and as a continuous stream. The following discussion is more concerned with phonemes - the coins of speech - rather than the gold reserves of continuous spoken language but there is a high positive correlation between measures of each.

The Phoneme Count Test 14 and the Voice Production Rating 24, teachers' assessment of continuous speech, for example, are closely related and a correlation coefficient of .80 is found between them (TABLE 20). It is possible to score the speech samples of the Phoneme Count according to the number of complete words accurately pronounced. The resultant Word Score (Variate 27) registers a coefficient of .936 when correlated with the Phoneme Count score.

Another means of relating the common sense values of continuous speech performance derived from teachers' ratings and the uncompromising empiricism of a literal count of phonemes accurately pronounced is to compute the mean % A.L. value for each rating category of Variate 24 thus:-

	$\bar{x}$ A.L. %
Cannot produce recognisable words	64
Very laboured speech which may be understood by those who have taught it	53
Can produce speech which is understood by those familiar with it at home and school	34

	$\bar{x}$ A.L. %
Speech may be occasionally intelligible to others besides family and teachers	28
Can produce fairly fluent speech, intelligible to the man-in-the-street.	11

These mean values per categories of Rating 24 were derived from the 15+ age group (Group C) so that by definition the % A.L. Variate 29 is equal in value to % S.P.A.L. Variate 30.

A similar mean phoneme value, % S.P.A.L., has been computed for the diagnostic grades of dyslalia shown in TABLE 5 (Ling, 1963) and serves to interpret the Phoneme Count in terms of a conventional classification.

Specific Speech Deficiencies

The discussion of the correlates of the Phoneme Count as a standardised test of general speech attainment will be resumed later for, at this point, it is proposed to deal with the use of this test as an instrument for the exploration and recording of specific speech defects and deficiencies and the assessment of difficulty levels of particular phonemes.

The order of difficulty of phonemes in particular word contexts is given in TABLE 10, using an extremely broad variant of the "Edinburgh" form of the International Phonetic Alphabet described by Abercrombie (1964). The broad classification of phonemes is appropriate to a practically biased study of the deaf in that in the speech training which this information is intended to aid, a very generous tolerance of unusual pronunciation or accent is acceptable provided it falls within the limits of intelligibility. Yet the limitations of the broad script are evident in TABLE 10 where it is clear that the /t/ in cat (35/60 correct) is only by a stretch of the imagination similar to the /t/ in tree (17/60 correct). Nevertheless the fiction of some 40 phonemes covering ordinary speech is profitable to maintain in speech training for deaf children where it is hoped that the context effect of adjacent phonemes in different sequences will modify the pronunciation of a given phoneme to accord with the variations expected in ordinary speech. Ignoring context in the compiling of an order of difficulty of phonemes results in the list shown in TABLE 11 which as it stands would be a reasonable guide to the selection of speech training vocabulary. Given the phoneme errors and deficiencies of a particular child a teacher could use this list to decide the order of presentation of remedial exercises designed to make good the omissions, presumably by beginning with work based on defective phonemes lowest in order of difficulty.

Error Analysis

Another clue to the ease of articulation of particular phonemes is the frequency with which they are used as substitutions for more difficult or less familiar phonemes. TABLE 10 shows the frequencies of preferred substitutes in brackets after each phoneme substitute and TABLE 12 shows the order of difficulty of substitutes for consonants.

Too often the kinds of error made by deaf speakers are simply disregarded and any inaccurate speech dismissed as educationally unprofitable. Again, the approach of the phonetician with his hardly won accomplishment of discerning fine discriminations in speech sounds tends towards a dismissal of the idea of error substitutes which are, necessarily, dependent upon the use of a broad script: with a narrow script what are formerly classified as substitutes often become sub-species or other phonemes. Under the broad approach of the Phoneme Count, however, which is geared to current methods of speech training, errors are seen as a fruitful source of understanding the specific difficulties deaf children experience in trying to speak.

The recorded errors of the 60 profoundly deaf children of Group E were examined and classified into three main kinds, namely omissions, intrusions and substitutes. Little noteworthy was observed about the first two kinds of error but many examples showed the distorting influence of English orthography, as in kanif for knife and the absence of phonemes from the velar zone, such as /h/, /g/, /k/ and /ŋ/, which are rarely visible to the lipreader.

Error substitutes may be grouped into "horizontal" and "vertical" substitutes according to the direction of displacement on the conventionalised plan of the articulators which has been designed by the present writer to summarise patterns of speech defects and deficiencies in clinic patients for diagnostic purposes. The use of this Diagnostic Articulation Chart is described later on page 143.

Horizontal substitutions are those made within an articulation zone or speech area such as bilabial, labiodental, alveolar, velar; e.gs. ban for man, stringk for string, den for ten; while Vertical substitutions are replacements with phonemes from distal articulators outwith the speech area; e.gs. dig for big, tree for three, key for knee.

Error substitutes may be further cross-classified into distinguishable types:-

Favourite substitutions occur when certain individuals attempt speech on a restricted phoneme repetoire with the result that they overwork one of their more intelligible phonemes and, as though delighted with this successful sound, uncritically attempt to fit it into any convenient articulatory hiatus; e.gs. jig, jo:t, ji: for dig, goat, key.

Habitual substitutions occur when a relatively rare phoneme sequence is overidden by a similar but more familiar phoneme sequence; e.gs. havn for have, after seven; tu:z for shoes, after two.

Approximations. Within the general broad tolerance of the intelligible any approximation is acceptable but with younger children cruder approximations may be acceptable. Thus early approximations may persist to an age level where they are no longer acceptable. Here there is a negative transfer of training from lipreading where approximation is useful. This leads to the dilemma of whether to accept approximations in speech to encourage language growth at the expense of intelligibility or to insist upon more accurate articulation with a consequent inhibition upon spontaneous expression.

Differential Error Analysis

What precisely are acceptable approximations? Are there any useful transitory errors? Perhaps the technique of differential error analysis may help to answer these questions.

By dividing Group E into six ability groups on the basis of total Phoneme Count scores an order of merit ranging from the highest scoring group of ten to the lowest was obtained as in TABLE 13. The mean articulation loss of the top ten was found to be 15 per cent, rising to 42 per cent for the third ten and to 80 per cent for the bottom ten.

A comparison of the kinds of errors and approximations of the various ability groups was made easier by this arrangement. The more intelligible substitutes made by the better speakers were noted as possibly more acceptable as an improvement upon the errors typical of bad speakers. Because Group D was deliberately representative of a wide age-range, largely coincidental with ability, a developmental path from apparently random errors, through increasingly acceptable approximations to accurate pronunciation may be traced for many phonemes.

Some differential frequencies of particular substitutions are shown in TABLE 13. For example, most of the top ability group give /ʃ/ in place of the initial /tʃ/ in chair and it can be assumed that the /ʃ/ substitute is more acceptable as a transitional approximation than the semi-vowel /j/ and the numerous voiced and unvoiced stopped alveolar consonants which appear in the lower ability groups. With the initial /ʃ/ in shoe on the contrary, most of the better speakers pronounce it accurately and the common substitute /t/ is not used by the top group and is not therefore acceptable as a useful transitional approximation, although it is preferable to the /j/ substitute used only by the poorer speakers. Similarly for the initial phoneme in jug, /ʃ/ is seen to be more acceptable as an approximation than /d/, whereas in the final phoneme in bridge (the "same" /dʒ/ in the broad phoneme classification) the partly correct /ʒ/ is more acceptable than the /ʃ/ substitute. In the dental consonants which are readily visible to lipreaders it would seem beneficial to discourage substitutes soon after the very early stages.

The deaf child's difficulty in unlearning speech habits is very considerable and an undiscriminating encouragement of remote approximations may have serious repercussions later. As a general rule, horizontal substitutions from within the same articulation zone are more intelligible and acceptable than substitutions from distal articulators. But as the above examples show, this is not always the case and the technique of differential error analysis is suggested as means of discriminating between useful approximations which should not be discouraged and unintelligible stop-gap approximations, facile approximations typical of lower age levels and dead-end approximations which prevent the development of more accurate articulation.

Concomitants of Speech Ability

Some of the many influences on speech ability may be examined by using the total score of the Phoneme Count, Test 14, as a measure of general speech ability.

The relationship of age to articulation is shown in the centre column of TABLE 8 and by the appropriate co-ordinate of FIGURE 2. A more detailed picture emerges from the age norms of Phoneme Count scores given in TABLE 9 where again an increase in speech ability with age is evident.

The difficulties of applying personality tests to the speech-handicapped have been discussed by Levine (1960) who reveals a sensitive understanding of the problems of deafness from the outside as does Gorman (1954), more vividly, from direct experience. The present study largely evades the rôle of personality in the ability pattern of the deaf but cannot ignore its considerable influence upon cognitive abilities entirely. All the evidence indicates that affective influences upon cognitive tasks are more important in deaf than in hearing subjects: the importance of good rapport between tester and tested, always important, assumes greater importance when a formal conversational relationship is not available as a substitute.

The approach to personality in the present work is confined to an analysis of teachers' estimates of personal qualities as evaluated on the rating form reproduced in APPENDIX C. The distributions of these ratings are shown in TABLE 24 and the mean and standard deviation of Phoneme Count scores is given for each frequency cell in TABLE 25. Thus the influence of speech upon personality traits and/or the influence of traits upon speech is made more obvious for inspection.

The steady rise in good behaviour (Variate 52) with speech ability has been noted by Simpson (1965) and is immediately evident from TABLE 25. This most likely indicates that speech attainment, like most other attainments is easier to acquire when no general behaviour problems exist or it may be in part a reflection of the values instilled into teachers during their exclusively orally-biased training resulting in some feeling of rejection and concomitant behaviour disturbances in non-oral pupils.

A similar increase in Energy (Variate 53), Dependability (Variate 56) and to a lesser extent Persistence (Variate 54) and Co-operation (Variate 58) accompanies an increase in speech ability and useable curvilinear relationships may be noted between speech scores and ratings of Aggression (Variate 55), and Confidence (Variate 57). The rather unexpected finding of high speech scores in the lower categories of Sociability Rating 59 probably reflects the unimportance of speech as a means of communication between deaf children. It is, obviously, much more difficult to lipread defective speech and if a deaf child wishes to exercise his ability to communicate orally with his school mates then he has to first of all belong to the 7 per cent who produce "fairly fluent" speech and secondly to choose a partner of equal speech ability from less than this 7 per cent (Montgomery, 1966b): in addition both must be competent lipreaders. The odds against the coincidence of these abilities are extremely high and as deaf children number about ten per class this 7 per cent comprises less than one child per class. It is not surprising if these gifted few occasionally forsake their hardly acquired oral skills and elect to join the vast majority of their school fellows who communicate fluently by manual methods.

Aetiological effects account for some differences in speech ability, perhaps because of the kind of organic differences described by Taylor (1967) under the dichotomy of peripheral and "language disordered" types of deafness but also because of environmental consequences of aetiological grouping. For example, the group whose congenital deafness is hereditary often have profoundly deaf parents who communicate by means of the manual alphabet and sign language and are by family tradition part of an essentially non-oral sub-culture. Again, those whose deafness is associated with infant meningitis are rated by their teachers as more aggressive and less well-behaved than other groups (TABLE 26) and as these ratings are associated with speech ability (TABLE 25) speech differences between aetiological categories are to be expected.

The relationship between speech ability and aetiology of deafness is shown in the 6th row of TABLE 23 where it is apparent that a greater mean articulation loss is characteristic of the hereditary group, followed closely by the meningitics. Comparison of Intelligence Test 10 (Raven's Matrices) scores shows that this poor speech performance does not coincide with lower intelligence in the hereditary group who have a higher mean intelligence score than all other groups, whereas the meningitic group have the lowest mean intelligence test score.

The numbers in sub-sample C when divided into the five crude aetiological groupings are too small to justify further treatment but it is sufficiently evident from the foregoing results that very different abilities, needs and problems occur within sub-groups of the profoundly deaf population. It is only the low incidence of profound deafness and consequent small number of pupils in schools for the deaf which makes classification for different educational treatments unrealistic (economically not educationally) in the present circumstances.

At the 11+ age level (TABLE 18) the Phoneme Count measure of speech ability shows substantial correlation with Lipreading Test 13 and Picture Vocabulary Tests 17 and 18. Significant positive relationships with Arithmetic Test 21, Formboard Test 9, Residual Hearing 33 and Intelligence Test 11 were also established. The general factor (Factor I) of the unrotated factor solution of TABLE 19 confirms the high communality of the Phoneme Count Test 14 which is to be expected from the role of speech as the communication medium which is officially to be taught and exercised in all other lessons as well as at meals and at play (Groht, 1958).

In the more comprehensive factorial analysis at 15+ (TABLE 21) the relationship between the Phoneme Count and other variates is usually higher than at the 11+ age level. In support of previous work denying the correlation of speech and intelligence scores (Myklebust, 1960) TABLE 20 shows that no significant correlation exists between the Phoneme Count and Intelligence Tests 4, 5, 8 and 9 which are all concerned with blocks or pictorial material. But in contrast to this previous finding (ibid.) Intelligence Tests 6, 7, 10, 11 and 12 are significantly related to Phoneme Count scores, although the correlation is not high compared to the close relationship with tests sampling other aspects of linguistic ability. The picture is slightly different for the Voice Production Rating 24 which is significantly associated with all intelligence tests save 5, 8 and 9 possibly because of a raters' "halo" effect.

The high correlation of speech with other tests and assessments of linguistic ability is shown particularly clearly in the factor solution of TABLE 21. The high loadings of speech Variates 14 and 24 on Factor VIII (lipreading) and Factor XI (vocabulary) confirms the interdependence of these various forms of communication attainments in the English language.

The two speech variates have the only substantial loadings on the relatively specific Factor V (residual hearing). The influence of hearing has thus been "taken out" from the interrelationships studied in this particular factorial analysis. It is as well to remember, however, that, illuminating as it is to partial out residual hearing in the interests of experimental accuracy, it is rarely discounted in the classroom, where, as TABLE 8 shows, it is increasingly operationally influential upon speech development. This influence is especially acute in the case of individuals with 100 per cent hearing loss (Groups D2 and C3) and as TABLES 1 and 15 indicate their speech abilities are not typical of the profoundly deaf as a whole.

This discussion of the speech ability of the survey sample is quite deliberately concluded with a reference to the importance of residual hearing for the development of speech in deaf children. To the present writer it seems a matter of some urgency that educationists cease to regard as "oral failures" children who are more accurately described as "aural failures" and that alternati ve means of developing language in these children should be employed.

Lipreading

The visual perception of spoken language via the movements of articulators and other facial cues is a receptive communication process commonly called lipreading. Many investigators prefer the word "speechreading" to describe this process presumably because many other cues are derived from the movement of tongue, teeth, cheeks and lower jaw in addition to lip movements. Quite recently, however, the emergence of a number of visible speech devices in schools for the deaf has made another kind of speechreading common. Thus it may be as well to use the general term speechreading to include the interpretation of the speech analogues represented by the configurations on neon, oscilloscopic and other visible speech devices and to reserve the term lipreading to indicate the oldest form of visible speech. Throughout this chapter the usage "lipreading" has been adopted save where an author's preference has been respected in listing books and references with the word "speechreading" in the title.

Evaluating previous studies Evans (1965) concluded that " . . . the search for factors influencing lipreading has, in the main, failed to yield promising results. The findings might best be regarded as inconclusive . . .". Inspection of the literature confirms this verdict and reveals that most investigations are too limited in scope to explore adequately the concomitants of such a factorially complex language process as lipreading. Some major influences producing "inconclusive", diverse and apparently contradictory results may be profitably recorded:-

Influence of Hearing. Pure lipreading is rare in practice as the majority of lipreaders use amplified sound as an aid. Hudgins (1960) demonstrated how children in schools for the deaf improve in speech recognition when sound is added to visual reception of speech. In the present investigations two measures of lipreading were used, one with and the other without the auxiliary use of sound via a personal hearing aid. The correlation between Test 13, (without a hearing aid) and Rating 23 (with the use of a personal aid and with speaker's mouth in good light) stands at .75. The term oral comprehension was used to refer to a combination of lipreading and residual hearing.

<u>Type of Test</u>. Another related influence having an obvious bearing on results is the type of test used. Two main types are the face-to-face test and the film test (Mason, 1943; Utley, 1946; Evans, 1965) and a comparison of different tests has been undertaken by Simmons (1959) and O'Neill and Oyer (1961). The face-to-face test allows a much more satisfactory establishment of rapport between tester and subject. The filmed test may cut out clues from residual hearing totally and hence measure an artificially pure form of lipreading and it would on apriori grounds seem to require more sustained visual attention from subjects. The advantage of filmed material is mainly in the standardisation of the visual input but, in practice, this is largely offset by the relatively inconvenient testing procedure. The apparent economy in using filmed material for group testing does not apply to the profoundly deaf who must usually be tested individually to prevent the rapid exchange of information during tests by manual signing. Again the filmed test is a two-dimensional representation of a three-dimensional original and differences between monocular and binocular perception may operate, although Goetzinger (1953) has established that such differences are not significantly related to lipreading ability in hearing adults.

Simmons found intercorrelations between face-to-face assessments of the order of r = .92 as against validity coefficients of .57 for the Utley film test and .61 for the Mason film test. The present study used a face-to-face test which compares favourably when validated against Teachers' Assessments (r = .75).

<u>Content of Tests</u>. Investigations differ in the speech unit employed as stimuli. At the most rudimentary level, some have studied the capacity to identify phones or phonemes. Others have chosen words as the test unit of speech perhaps demanding a written or spoken response to ascertain comprehension but more usually demanding a choice of pictures of objects hence limiting the vocabulary employed to less abstract, picturable words. Finally, more operationally realistic tests of lipreading employ sentences, consequently bringing in the important clues from context and grammatical structure upon which the skilled lipreader depends heavily.

The work of Woodward and Barber (1960) has shown the considerable areas of confusion which exist between isolated phonemes perceived visually and more recently Woodward (1963) has classified English monosyllabic words according to a systematic scheme of visual comprehensibility. Her proposed reference manual for lipreading vocabulary grades words by use of the following linguistic criteria.

1. Absolute and relative visibility of component articulations,
2. Number of homophenes (e.g. /p/ is visually equivalent only to /b/ and /m/, whereas /t/ may be confused with any of 15 equivalents),
3. Frequency of occurrence.

Franks (1966) has confirmed that context operates at the word perception level so that the perception of an initial phoneme is influenced by the linguistic characteristics of a known word stem and in particular that there is a significant difference in the accuracy of lipreading the same initial consonant when it is united with different stems.

The use of longer, more complex and more meaningful speech units promotes a connection with the comprehension of language, verbal ability and intelligence. Early studies such as that of Pintner (1929) found no relationship of lipreading and intelligence mainly because of the use of tests depending on the recognition of simpler units of speech. O'Neill (1956), Costello (1957), Simmons (1959), Myklebust (1960), Evans (1965) and Montgomery (1966b) have each confirmed that lipreading, variously measured, is positively correlated with some measure of intelligence or general mental ability.

The present investigation found that the ability to organise language into sentences apparently outweighed the narrower visual perception skills when the standardised Lipreading Test 13 was compared with Teachers' Assessments of Oral Comprehension 23 and Written Composition 25. The composition rating was essentially about the ability to write sentences and Test 13 was a test based mainly on the visual comprehension of sentences: the correlation coefficient of these two variates stands at .85 which is higher than the .75 reported above between the two lipreading variates Test 13 and Rating 23.

<u>Population</u>. A final major source of divergence between research findings is obviously due to the fact that very diverse populations have been sampled by different investigators. O'Neill (1951) and Goetzinger (1963) have studied lipreading ability in the normally hearing; Costello (1957), O'Neill and Oyer (1956) and Evans (1965) have tested samples of partially deaf and deaf subjects and Myklebust (1960) has compared day school deaf pupils with their counterparts from residential schools. Costello (1957) and Evans (1965) found differences in lipreading ability between deaf and partially hearing samples in favour of

the partially hearing and the obvious use of structured language to a lipreader leads the present writer to expect that most linguistic and communication skills, including hearing, would be positively correlated with lipreading ability in a sample of loosely defined "deaf" people. In the present study, selection by residual hearing has ensured that there is a narrow range of hearing loss within the sample and no significant relationship between residual hearing and lipreading ability obtains but a substantial positive correlation with all other measures of linguistic ability is clearly evident.

The age of the sample under study has often been found to be related to lip-reading skill. Hudgins (1960) described the non-linear age curve typical of lip-reading scores and Evans (1965) also found this effect. The latter study found scores to increase rapidly between eight and eleven years and then to level off. Goetzinger (1963) examined a sample aged 18 to 37 years largely consisting of student nurses with normal hearing. In this group he found that the ability to lipread was negatively correlated with age and in his discussion reminds us of the previously reported negative correlations with age in the study by Simmons (1959) which were not, however, significant in the small sample which she studied.

The rôle of age in the present study has been substantially reduced by a narrow age range within most sub-samples. Within Groups B and C age does not correlate significantly with either measure of lipreading. A comparison of the correlation coefficients of Lipreading Test 13 with seven variates at 11+ and again at 15+ is presented in the correlational profiles of FIGURE 4. It may be noted from this table that the A.P.U. Attributes Test which is not significantly related to lipreading scores at 11+ becomes significant well beyond the .01 level at the age of 15+. The two tests of written vocabulary are similarly much more relevant to lipreading at 15+ than at 11+, while the relationship of speech to lipreading is remarkably similar at both age levels.

Another population influence upon lipreading performance may be the sex of the subjects. Evans (1965) found that the girls in his sample achieved a mean score of 62 per cent against the 48 per cent recorded for boys: this difference was on the borderline of significance, just below the .05 level. An analysis of a much larger sample of over 700 deaf school children by Myklebust (1960) found that lipreading ability was significantly related to the sub-scores of the Picture Story Language Test in all groups of deaf children except for boys in residential schools.

Inspection of the Oral Comprehension section of TABLE 14 suggests that Teachers' Assessments of lipreading favour deaf girls but a formal comparison by biserial correlation coefficient establishes that this difference is not significant at $r = .137$. The equivalent biserial value for Lipreading Test 13 is a correlation coefficient of .236 which is just below significance at the .05 level. Treating the categories as non-parametric, the same section of TABLE 14 yields a chi squared value of 4.15 which is not statistically significant.

Concomitants of the Lipreading Process

How lipreading is assessed, what aspects of speech are used as stimuli and who is assessed are weighty determinants of lipreading ability and, to some extent, help to define this complex skill. It may help to clarify this problem of definition if we regard lipreading as a cluster of interrelated skills and consider them as separately measurable aspects of an integrated process under the headings of acuity, attention, perception, retention, recognition and comprehension.

Visual Acuity. It has long been evident that defects ofhearing may have a common origin with associated visual defects. The career of Helen Keller drew early attention to the particular problems of the deaf-blind and the work of Carruthers and Gregg (1942) in Australia at the end of the war described the rôle of maternal rubella in the first three months of pregnancy as a common source of hearing and visual defects. In a recent analysis of some 19 different syndromes associated with congenital deafness Fisch (1963) found visual defects to occur in eight of these syndromes. Sometimes more specific defects occur as in Usher's syndrome in which deafness is linked to retinitis pigmentosa and night blindness ensues.

A higher incidence of visual defect in deaf children than normal has been found by Braly (1937) who found 38 per cent of deaf children to be visually defective, Stockwell (1952) who found 45.5 per cent visually defective and Myklebust (1960) who found 51 per cent with one or more defects and 30 per cent with two or more defects. The present study (TABLE 22) found 31.8 per cent had had spectacles prescribed and that 21.2 per cent of these continued to need refraction. (Some 15 per cent of the hearing school population need refraction according to Stockwell (1952)).

Given that associated visual defects in the deaf have long been recognised it is surprising that these have rarely been investigated with regard to lipreading ability. An exception is Evans (1965) who tested 64 children with the Snellan charts and found a biserial correlation coefficient of -.10 between a normal/defective classification and a filmed test of lipreading. But unless there were an unusually high incidence of defectives the biserial distribution must have been rather too lop-sided to make this coefficient reliable. Furthermore, it appears from his description that the ages of his sample ranged from 8 to 16 years and that some partially deaf children were included so that these results cannot be accurately represented as typical of "the deaf" as a whole.

The present study with more rigorously controlled limits of age and hearing loss found that those deaf adolescents who currently had spectacles prescribed were significantly poorer lipreaders according to their teachers' ratings than their class-mates with normal vision (TABLE 22). The chi squared test applied to a spectacles/no spectacles classification against a dichotomy of Rating 23 at the median i.e. average categories and below/above average categories resulted in a chi squared value of 4.907 (with Yate's correction) which is significant at the .05 level. Contrary to the writer's expectation no difference occurred between those with normal vision and the few who wore spectacles in their early schooldays and have since discarded them. Lipreading begins spontaneously in many deaf children at a very early age and is encouraged by the home guidance service whereby qualified teachers of the deaf visit deaf children before the admission to nursery school, usually at the age of three. Experience of pre-school children in an ascertainment clinic and observation of nursery-school children left a subjective impression that many non-lipreaders at this age are visually handicapped.

Inspection of the part of TABLE 22 concerned with Lipreading Test 13 shows that the mode of the normal vision group is in the 30 - 34 class interval while the mode of the two visually deficient groups is in the 20 - 24 class interval. These observed differences are not statistically significant however. A dichotomy at the median 5 - 29/30 - 40 against a spectacles/no spectacles classification yields a chi squared value of 2.10 (with Yate's correction) which is not significant at the .05 level. Inclusion of those who used to wear spectacles in early childhood into the "spectacled" group results in a closer association between lipreading ability and visual acuity giving a chi squared value (with Yate's correction) of 3.173 which just falls short of the value of 3.841 which represents significance at the .05 level. Comparing the means of the normal ($\bar{x}$ = 28.44, s.d. 6.72) and defective ($\bar{x}$ = 25.57, s.d. 7.88) groups a difference of 2.87 was observed. The t value of 1.230 was not statistically significant. In that Lipreading Test 13 makes demands upon the ability to comprehend sentences it may be more remote from visual acuity than the Oral Comprehension Rating 23.

Visual Attention. Unlike the ears, the eyes may be shut. The constant background monitoring of the environment by the hearing mechanism has no close equivalent in the process of visual perception. Vision is a much more selective system of sense-data reception than hearing and visual vigilance is more demanding and unreliable than auditory vigilance. Thus the profoundly deaf person cannot easily substitute an all-round visual vigilance for his lack of hearing. In lipreading, a momentary glance elsewhere means the loss of a few words and perhaps the consequent loss of context results in lack of comprehension or complete misunderstanding.

The normal child's capacity for inattention to very loud sounds is considerable and this adds greatly to the problems of early ascertainment of deafness. Some children reinforce normal inattention with a sustained disregard of sound while visually engaged and this selective áttention may be developed to the point at which they may be misdiagnosed as deaf. Broadbent (1958) has discussed a number of experimental conditions under which selective listening to speech may be examined and quotes a series of experiments by Mowbray (1952, 1953, 1954) which compared visual and auditory reception. Mowbray concluded that successful division of attention did not occur under the conditions of simultaneous presentation of independent data to eye and ear which he employed. Where visual and auditory information are synchronised as in lipreading there is an apparent division of attention and, as Hudgins (1960) portrays graphically, an increase in reception over data presented via a single sensory channel. In fact, attention may not be divided at a single point in time but some alternation in attention may occur and the least useable information from one sensory channel could be discarded while material from the other channel was being assimilated. As Broadbent points out, the rate of input is important in deciding whether or not "Two tasks at once are impossible" and where the rate of arrival of information is low then to some extent two tasks may be handled at once.

In the ordinary social context, lipreading demands undivided attention and communication is restricted to one other person at a time at reasonably close quarters. The consequent limitation of communication is considerable.

Few direct studies of attention and lipreading have been published apart from that of Frisina and Cranwill (1963). These investigators subjected deaf and hearing adults to the Continuous Performance Test (Rosvold, 1956) with the object of investigating their ability to maintain sustained visual vigilance. No difference between the deaf and hearing was found and within the deaf group no difference between proficient and inefficient lipreaders was found. Thus despite the common-sense expectancy that attention is a sine-qua-non of visual speech reception no general ability to sustain attention influences aptitude for lipreading.

Visual Perception. Comparative studies of visual perception in deaf and hearing subjects have been completed by Myklebust and Brutten (1953), Larr (1956) and Snijders-Oomen (1959). The first three named using figure-ground perceptual tasks found no compensatory skills in visual perception among the deaf. In the Snijders-Oomen test battery standardisation on 1054 deaf and 1400 hearing subjects the following differences at the .01 level of significance in tests with a considerable visual perception component were noted:-

Block Design	deaf superior
Picture Completion	hearing superior
Picture Series	hearing superior

Costello (1957) in a comparison of deaf and hard-of-hearing populations in lipreading and visual perceptual tasks found significant correlations with the Weschler Picture Arrangement Test and lipreading ability in both groups. O'Neill (1956) found no significant relationship between tachistoscopic digit recognition and the Mason film test but Evans (1965) found a substantial coefficient of correlation of .48 between a Visual Recognition of Designs test and his own film test of lipreading.

The present study found many correlates of lipreading ability at 15+ among tests with a high visual perception content. Lipreading Test 13 showed a high correlation with the two tests of perceptual speed, Visual Word Discrimination Test 19 and Number Perception Test 20 and significant correlation was established with the two S.O.N. Tests, Block Design Test 4 and Picture Series Test 6. The Oral Comprehension Rating 23 showed substantial correlation with the perceptual speed tests 19 and 20 and significant correlation with the S.O.N. Tests 4 and 6. Factor VIII of the rotated factor solution of TABLE 21 may be reasonably assumed to be a group factor of lipreading abilities. Here the relatively high loadings on perceptual speed tests 19 and 20 are again evident and Picture Series Test 6 also shows a substantial loading.

Visual Retention. The rôle of memory in lipreading ability has not been precisely established but some relationships between specific memory tasks and lipreading ability have been recorded. Costello (1957) found that the deaf were significantly better than the hard of hearing on the Knox Cube Test but that this test did not correlate significantly with lipreading ability. The standardisation studies of the Snijders-Oomen Test (1959) showed that deaf and hearing subjects were equal in performance on the two memory tests Picture Memory and Knox Cubes. In the present study neither Picture Memory Test 5, nor Knox Cubes Test 8 appeared to be important correlates of lipreading ability. Picture Memory Test 5 did not correlate significantly with either of the lipreading variates and the significant correlation of the lipreading variates with the Knox Cube Test was not maintained in the factor solution where Factor VIII shows a zero loading on Test 8.

One of the memory tests in the Costello study (1957), the Visual Digit Span which utilises numerical symbols did correlate significantly with lipreading ability although Simmons (1959) did not find digit span perception to correlate significantly with lipreading. It may be noted at this point that Number Perception Test 20, which has been discussed under the previous section under the heading of visual perception has, in fact, a slight memory component and may be regarded partly as a test of visual digit span. The H-board apparatus employed in Tests 19 and 20 ensures a slight delay between the recognition of the stimulus and the perception of a matched equivalent and may be used to introduce a delay between stimulus and response in tests of visual perception thereby increasing the demands upon visual retention in the performance of such tests.

Visual Recognition. In some tests involving matching processes all the information is laid out visually before the subject as in Block Design Test 4 and tests of perceptual speed 19 and 20. Another kind of test presents a matching problem in time and the recognition of similarities is tested by recording a briefly delayed response. When the matching matrix is not presented, however, the subject must draw upon his own knowledge to effect a match and this kind of long-term remembering and association is described as visual recognition in this section to differentiate it from the other matching processes more appropriately described under the headings of visual perception or visual retention.

Costello (1957) found a significant relationship between the Gates Reading Test and lipreading ability and Myklebust (1960) reported a significant correlation with lipreading and the Columbia Vocabulary Test. Myklebust further noted that in deaf school-girls and boys in day schools for the deaf lipreading was associated significantly with syntax, sentence length and abstract/concrete thought scores on the Picture Story Language Test.

The present study found that spoken and written vocabulary at 11+ and 15+ (FIGURE 4) were important correlates of lipreading ability. At the 15+ stage FIGURE 3 shows that Speech Test 14, written language tests 15 to 19 and language ratings 24 and 25 all correlate substantially with the two measures of lipreading ability, 13 and 23. In the factorial analysis of TABLE 21 the loadings of Factor VIII (Lipreading) on the written vocabulary tests 16, 17 and 18 are lower than what the individual correlations with variates 13 and 23 would lead one to expect. Substantial loadings are maintained on Speech Test 14 and Vocabulary Test 15, however. This result is partly explained by the fact that a vocabulary factor (Factor XI) has been taken out and, incidentally, this factor has a substantial loading on the Lipreading Test 13.

The findings of the present study support Costello's contention that the "richness of inner language" may be the critical influence which determines lipreading ability. In the absence of visual recognition lipreading skill drops dramatically and even the most efficient of lipreaders cannot be expected to comprehend the visual speech movements of a person speaking an unfamiliar foreign language. Thus to a great extent the good lipreader must know what speech sequences to look for. Unfortunately the profoundly deaf whose dependence on lipreading is greater than other groups have less "inner language", less spoken and written vocabulary to draw upon and utilise in visual recognition processes.

If one accepts the idea of inner language as a main component in the visual recognition of speech then the educational treatment of deafness should seek to facilitate positive transfer of training between the language processes of reading, writing, speaking, the transmission and reception of manual communication and lipreading.

<u>Comprehension</u>. It is possible to receive a visible impression of speech and to imitate this orally without comprehension. But the perception of meaningful data is easier than the perception of meaningless data and consequently any discussion of lipreading ability cannot omit the influence of intelligence and ignore the visual comprehension of speech by concentrating on less complex perceptual processes.

Many early investigators using tests which made little demand on contextual cue-seeking or global comprehension found that intelligence tests did not correlate with lipreading scores. Pintner (1929), for example, found no such relationship and Costello (1957) found no significant relationship between Raven's Progressive Matrices and lipreading ability in the deaf although a significant correlation in the hard of hearing was obtained. Another study apparently denying the relevance of intelligence to lipreading ability is that of O'Neill and Davidson (1956). These investigators compared the scores of the Mason film test with the results of Intelligence and Reading Comprehension scores on the Ohio State Psychological Examination and found non-significant correlation coefficients (rho) of .03 and -.03 respectively. These results may be dismissed as largely irrelevant to the training of deaf pupils in lipreading as they were derived from a normally hearing group who were without previous experience or training in lipreading. In addition this population were, in fact, undergraduate students who could be expected to be highly selected and therefore homogenous with respect to intelligence and attainment variates and this effect alone could be expected to result in a substantial depression of correlation coefficients employing these variates.

Subjective observation of deaf children engaged in lipreading exercises in the classroom leaves the present writer with little doubt that intelligence and general scholastic ability are important for the attainment of good lipreading. Many of the correlates of the visual perception processes listed above, form part of batteries of tests used in various intelligence scales. Using as a measure of intelligence the visually orientated Draw-a-Man Test Myklebust (1960) found significant differences between the means of a "Fair-Poor" group of lipreaders and an "average plus" group in favour of the latter.

The present study showed lipreading ability at 15+ to be substantially correlated with a number of intelligence test scores (FIGURE 3). Written tests of intelligence, on the whole, proved to be more closely related to lipreading ability than were performance tests 4 to 9 and the Abstractions Test 12 registered a correlation of .63 with Lipreading Test 13.

The complexity of the lipreading process has been emphasised by Oyer (1963) who approached the subject from the standpoint of experimental psychology and lists variates such as light, distance, speed of presentation, distraction and the differential visibility of various languages as important considerations. From the approach of psychometrics and factorial analysis, the present study also emphasises the complexity and communality of lipreading ability, as inspection of TABLES 20 and 21 and FIGURE 3 will confirm. The popular notion of the existence of a specific all or nothing flair for lipreading is largely due to the fact that it is an esoteric skill rather mysterious to the unsophisticated which, like sword-swallowing, demands specialised training and is rarely practised by the average man-in-the-street.

Manual Communication

Under the present hegemony of oralism in the education of the deaf in Britain the manual method of communication is not officially approved but continues to flourish underground much the same as did the English language in the centuries immediately following the Norman conquest.

The distribution data of TABLE 14 confirms previous estimates (Montgomery, 1966b) which indicated that over 70 per cent of profoundly deaf children are able to communicate fluently with the adult deaf by means of the finger alphabet. Outwith the educational system manual communication is universally accepted as the main method of communication between deaf adults and is widely used and taught by the voluntary associations and institutes for the adult deaf (Nat. Inst. Deaf, 1956; Long, 1958; Scot. Assoc. Deaf, 1959). This disastrous divergence of policy between educational and welfare organisations is hardly conducive to helping the deaf school leaver with his considerable social and occupational adjustment problems and in itself is an example of faulty communication which deserves study in its own right.

The reliance of the deafer pupils on manual communication at school is suggested by TABLE 15 which shows only 4 out of 22 are below average for this ability as against half of the sample who cannot produce speech above the "very laboured" category.

The overwhelming preference of the profoundly deaf for manual methods is best explained by Myklebust (1960) who points out that, in contrast to the hearing child who uses a receptive auditory inner symbol system to monitor expressive language in the same sensory mode, the deaf child must use a receptive visual inner symbol system to monitor the same expressive language which, to him, is in a different sensory mode. The consequent difficulty of transferring from visual to auditory symbol systems may cause many deaf people to prefer the expressive and receptive forms of manual communication which are mainly confined to the visual mode.

Much of the literature on manual communication is not directly descriptive of this communication medium as a process but is concerned with its effectiveness in the educational setting. Doctor (1950) draws attention to the importance of teaching valid and useable concepts to deaf pupils and, with sound American pragmatism, advocates the use of whatever communication process is effective as a means to this end in individuals. For most pupils this approach would favour a combined method which reinforces speech and lipreading with the simultaneous use of manual communication. Morkovin (1960) and Titova (1961) have described this approach with very young children in the U.S.S.R. who eventually learn to communicate without resort to manual methods. Birch and Stuckless (1964) emphasise the influence of the family tradition of communication and find that the use of early manual communication in the home is usually beneficial educationally. A detailed tabulation of the benefits of changing from an oral system to combined methods in a particular school has been completed by Hester (1963).

An experimental trial of teaching the Paget sign system (1952) to a group of the more backward of very young deaf children has been reported to the present writer. This departure is interesting in that it shows a reversal of the technique described by Morkovin and Titova: instead of beginning with concept training via the easy route of sign language and graduating to oral language this method is essentially selective in that only "non-oral" pupils are allowed the help of signs. It would not be surprising if the sign-using group began with a sense of rejection or failure and this effect would vitiate any comparison of oral and manual groups. This selective effect is important in any study which seeks to evaluate oral as against manual pupils in an orally biased educational climate and it is probably operative in the present investigations. In other words, it is unfair to compare an attainment which is taught at length and everywhere encouraged with one which is officially prohibited but tolerated in a few cases of outright "oral failure".

Another reservation about the nature of manual communication as represented by Variate 26 is that it is a rating by orally trained teachers who do not, necessarily, understand how to communicate manually themselves. No standardised test of manual communication was employed (none exist) and dependence upon Rating 26 for a measure of manual communication ability is complete. In fact, TABLE 14 shows the heavily skewed distribution of the original rating categories of manual communication and the eventual crude class interval adopted to offset this skew in Variate 26 resulted in a depression of the values of the correlation coefficients associated with Manual Communication in TABLE 20. This depression also had the effect of diminishing the communality of Variate 23 in the factor solution so that Factor III (manual communication) emerges as more specific than would be expected without the confluence of educational and statistical circumstances outlined above. Comparison of the results of TABLE 17 based on a small sample of school leavers (Group C2; n = 42) shows more realistic correlation coefficient values between Manual Communication and other variates. But in this case, results are based on direct correlation of the ten categories of the Manual Communication Rating of APPENDIX B which gives a slight over-estimate. For example, the correlation coefficient of Manual Communication with the measure of concept attainment, S.O.N. Sorting Test 3, stands at .480 whereas a dichotomy at the median, eliminating the skewed distribution of the Manual Communication variate, results in a correlation coefficient of .438.

It may be noted at this point that Manual Communication Rating 26 is mainly concerned with the finger alphabet and only categories 9 and 10 generalise to include the conventional sign language. But "pure" finger-spelling devoid of signs is extremely rare unless children have been schooled deliberately in the Rochester method (Galloway, 1963) whose advocates prohibit signs but encourage the use of fingerspelling as an aid to oral and written verbal skills.

Concomitants of Manual Communication Ability

Despite these considerable reservations about Variate 26 it is nevertheless profitable to trace the correlates of Manual Communication in the factorial study of Group C.

Many significant relationships occur between Manual Communication Rating 26 and the test battery intercorrelations assembled in the correlation matrix of TABLE 20. Intelligence tests 7, 10 and 12 show such significant relationships as do vocabulary tests 15, 17 and 18, the perceptual speed tests 19 and 20 and the arithmetic test 22. None of the other teachers' estimates of speech, lipreading and written work correlate significantly with their estimate of manual communication - possibly because of a "horns" (as opposed to halo) effect operating against the practitioners of this forbidden art. This latter probability is enhanced by the significant correlations obtaining between manual communication and standardised tests of speech, lipreading and written vocabulary.

At the factor level TABLE 21 shows a rotated solution which establishes Factor III as a relatively specific factor with a high loading on Manual

Communication Rating 26 but with substantial loadings on written vocabulary tests 15, 17 and 18 and Visual Word Discrimination Test 19. This confirms the association of manual communication and written vocabulary noted by previous workers (Quigley and Frisina, 1961).

The other relationships noted in the correlation matrix are reflected in the factor solution. Factor VIII (lipreading) which is highly loaded on many other language tests shows the next highest loading of Rating 23. The next highest loading, after this, for Rating 23 is on Factor X which confirms the relationship of Manual Communication and non-verbal reasoning tests.

This latter finding confirms the less reliable relationships which are set out in TABLE 17 relating Manual Communication to concept attainment and to other intellectual abilities, lending some support to the contention that manual methods provide an avenue for the promotion of structured relationships which are beneficial to the mental and educational development of deaf children.

Written Language

The usual way of regarding written language as an attainment masks its equally valid role as a means of communication: the first viewpoint emphasises the acquisition of linguistic content and the forms of language while the second viewpoint tends to evaluate written language as a channel to general understanding. Certainly in schools for the deaf, the blackboard dominates the learning situation and two-way use of the blackboard by teacher and pupils is more common than in other schools. To many deaf persons the written form is their main contact with their mother language and some have developed reading and writing to the exclusion of more immediate forms of communication such as the oral and manual methods. One advantage is that accurate communication is possible with persons who are not conversant with the more esoteric modes such as lipreading, fingerspelling, sign language and the speech of the deaf which is usually unintelligible to the uninitiated.

According to Harriet Kopp the receptive aspect of written language dominates the educational scene. "Reading is probably the most important single subject which we teach to the deaf child. It provides the major avenue through which he will learn and constitutes his chief and most accurate information input channel." (Kopp, 1963). In contrast to the hearing child, who develops a vocabulary via listening, speaking, reading and finally writing, the orally trained deaf child acquires his vocabulary first by lipreading or manual methods, then by speaking in conjunction with auditory learning and then by reading and writing. The relative size of initial vocabularies is influenced by this developmental sequence but the eventual proportions are somewhat different, thus:-

Eventual Relative Size of Vocabularies (Kopp, 1963)

	Reading	Writing	Lipreading or Manual	Speaking	Hearing
Deaf Children	1st	2nd	3rd	4th	5th
Hearing Children	1st	3rd	-	4th	2nd

In both deaf and hearing groups the receptive form of written language is the main source of vocabulary and in the deaf group the expressive form of written language is the second main source of vocabulary.

In the present study the main measures of expressive written language are the Picture Vocabulary Tests 17 and 18 and the assessment of Written Composition, Rating 25. The Mill Hill Vocabulary Tests 15 and 16 are both verbally receptive and expressive and the Visual Word Discrimination Test has a component of receptive verbal vocabulary recognition.

Incidentally, the different relative size of the various kinds of vocabulary tabulated by Kopp indicate that the assumption of the equivalence of oral and written forms of vocabulary sometimes made by tests and testers is only very roughly justified. For example, Templin (1963) in a comparison of deaf and hearing children's usage of vocabulary, credited the hearing group with responses made orally as well as in written form and the Mill Hill Vocabulary Scale extends norms to the age below which written vocabulary is testable, by using an oral test. In the hearing population, however, oral and written vocabularies are much more integrated than in the deaf population. The present study (TABLE 20) does show high correlations between Speech Test 14 and the assessments of written vocabulary and composition but in the factor solution of TABLE 21 Speech Test 14 has higher loadings on the Factor V (hearing) and Factor VIII (lipreading) than on Factor XI (vocabulary).

Another feature of the interrelationship of various kinds of vocabulary attainment in the 15+ (Group C) study is that the open-ended response tests 15, 17 and 18 show a similar correlational profile in contrast with the multiple choice test 16 which is not so highly correlated with all other tests in the battery. The fact that the training of deaf children encourages approximation and that many of them will usually make a "happy guess" rather than lapse into inert inactivity seriously vitiates the validity of multiple choice techniques with few alternatives for use with the deaf. Responses to the more difficult items of the Mill Hill Synonyms Test 16 showed that blind guessing had occurred and the fact that the Instructions Manual permits this attitude and allows for it in the norms for hearing children does not in any way increase the validity of this test for the deaf population whose numerous guesses usually outweigh their considered responses and introduce a large random element into the deaf norms. Factor IX in TABLE 21 retains this contrast of Test 16 with the other vocabulary tests.

Much has been written on the presumably antithetical nature of abstract and concrete vocabulary but little support for this dichotomy exists in established records of actual test performance. Templin (1963) for example using the Moran Word list of ten "thing" and fifteen "non-thing" words studied deaf and hearing childrens' performance on three tests of word meaning and three tests of word usage at three age levels, 6 years, 9 years and 12 years and retested at 8 years, 11 years and 14 years. The conclusions drawn from this study mainly establish that the changes in the older deaf childrens' vocabulary over two years are rather similar to the changes of younger hearing children over the same period. This is covertly aimed at supporting the "genetic" approach to speech training which claims that the normal developmental course of speech acquisition should be pursued by the deaf child if, of necessity, at a slower rate. This view is in contradiction to those who contend that deafness imposes its own patterns of speech development with particular problems which are dissimilar to the development of speech in hearing children (Myklebust, 1960; Kopp, 1963). But the incidental findings of the Templin study are of more direct relevance to the abstract-concrete issue and the finding that " . . . differences in performance of both the deaf and hearing on the "thing" referent and "non-thing" referent words are such that generalisations which apply equally to all of the several tests cannot be made" argues against a clear cut division of abstract and concrete vocabulary on such practical lines.

In the present study the picture vocabulary tests required children to name picturable "things" while all but some 7 out of 66 items of the Mill Hill (Junior) Vocabulary tests were "non-things". Thus the Mill Hill test is "unfair" to deaf children who do not develop abstract vocabulary readily. Nevertheless, the high correlation between "abstract" vocabulary test 15 and the two "concrete" vocabulary tests 17 and 18 lends support for the idea of a common factor of written vocabulary and not for separate factors of concrete and abstract vocabulary. The relatively low relationship of the two "abstract" tests 15 and 16 confirms this idea and, in fact, TABLE 21 shows Factor XI as a written verbal factor with high loadings on vocabulary tests regardless of the degree of abstractness or concreteness of the content of these tests. Again in TABLE 17 where the Mill Hill (combined scores) was compared with Picture Vocabulary Test 17 a substantial correlation coefficient of .72 was obtained.

Inspection of the actual scripts of the Mill Hill tests shows the deaf in an unfavourable light, for in addition to the mindless guessing already noted in Test 16, Test 15 in the vast majority of cases reveals a perseverative repetition of the form of the initial example "a kind of . . . . . ." which gives an impression of rigidity and lack of originality. Often the "a kind of . . . . . ." introduction is written opposite all the stimulus words although definitions are only attempted for the first few easier words. There are adequate explanations for these characteristics of the deaf in their responses to this test which are usually conditioned by their education. Given their limited vocabulary, the deaf and their teachers are usually content to acquire a single, preferably a lipreadable, word to indicate an object or concept and regard synonyms as something of a luxury. For example, having acquired the word "clever" which is short and eminently visible to the lipreader few deaf children would trouble to learn the words "intelligent" and "intellectual" which are (a) longer (b) less visible and (c) different in meaning only at a level of verbal sophistication beyond them.

When the scripts of the Picture Vocabulary Test are examined, however, the impression gained of the deaf appears to be much more favourable. These tests are standardised on a deaf population and do not depend on verbal receptive processes but demand a written verbal response to pictured objects. Again the limitation of vocabulary due to reduced auditory input is evident but to a lesser degree. In place of the rather ineffective strategies adopted in the Mill Hill tests, however, considerable ingenuity is revealed in responses to pictures where acceptably correct responses are not known as these actual examples indicate:-

Correct Response	Improvisations
crossword	numberpaper, quizsquare, crossed-puzzles
tartan	Scotlandknit, weaverwool

Correct Response	Improvisations
caravan	car-van
helicopter	helicrope, haeoroplane, helicopper, hepbillon, hicotoper, helicoption, wheelpane.

Here one sees a reflection of the ingenuity deaf children show in adapting, reorganising and ringing the changes on the relatively small number of conventional manual signs available to express personal, new or particular ideas.

The relatively slow input of vocabulary in deaf children engenders a stability in the content of their verbal repetoire which makes vocabulary tests particularly reliable. The alternative forms A and B of the Picture Vocabulary test show another aspect of this reliability yielding reliability coefficients of .94 (TABLE 18) at the 11+ stage and .91 (TABLE 20) at the 15+ stage.

In the latter study (Group C) a sex difference favouring girls was noted in Mill Hill Synonyms Test 16 and Picture Vocabulary Test 17. The differences were slight but significant at the .05 level. The distribution of the Written Composition Rating 25 shown in TABLE 14 again, on the face of it, indicates a better performance by girls but the biserial correlation coefficient did not attain conventional levels of significance.

Concomitants of Written Verbal Tests

In the 11+ battery, Tests 17 and 18 show substantial correlation with all other tests except Residual Hearing Variate 33. At this stage Speech Test 14 is particularly closely associated with written vocabulary.

The association of written verbal tests with most other tests of language, intelligence and number is again apparent at the 15+ stage. The correlation matrix of TABLE 20 confirms this and the only non-significant correlates of the written verbal tests 15, 16, 17, 18, 19 and 25 are Residual Hearing 33 and the performance tests 5, 8 and 9, with a few additional non-significant correlates of particular tests; namely, Test 4 is not significantly related to Tests 16 and 17, Rating 26 is not significantly related to Tests 16 and 19, and Tests 6, 7 and 10 are not related to Test 16.

These interrelationships are more clearly summarised in the rotated factor solution of TABLE 21. The main factor of verbal attainment is clearly identifiable as Factor XI which has highest loadings on tests of written vocabulary but also has substantial loadings on Test 19 which has a verbal component. Speech tests also show a substantial loading on Factor XI in contrast to the zero loadings of all vocabulary tests on Factor V which may be regarded as a hearing-speech factor. The next highest loadings to manual communication on the relatively specific Factor III are the loadings of all vocabulary tests except Test 16. This association of vocabulary and manual communication has already been noted as confirming the finding of Quigley and Frisina (1961) that these two abilities are positively correlated. Finally the substantial loadings of all vocabulary tests on Factor VIII (lipreading) may be again added as confirmation of the Costello (1957) thesis that "inner language" is important in the development of lipreading skill.

In general, the high communality of tests depending on written verbal ability largely substantiates the Kopp claim that understanding of the written word is the most important medium for the reception of information available to a deaf child: certainly the close association with many other forms of attainments does suggest that written language skills permeate the curriculum of schools for the deaf.

Numerical Ability

The verbal handicap associated with profound deafness promotes a backwardness in language skills which, on the face of it, would not overspill into numerical abilities. To some extent this is true, and deaf children are not so retarded in number attainments as in verbal attainments. But some backwardness in mathematical skills does occur, probably due to the fact that the protracted acquisition of linguistic skills in schools for the deaf leaves pupils relatively little time for non-linguistic attainments in the early part of their school career. Another handicap may be that language facilitates the codifying and memory storage of non-verbal mathematical operations and allied problem solving strategies, especially in the more advanced stages. Sometimes mathematical problems are expressed in verbal form which is beyond the vocabulary of the deaf subject. Again, if the test uses a conventional notation alien to the experience of the subject this will often handicap the deaf more than the hearing child: with his restricted information input the deaf child is much less likely than his hearing age-mate to know that the forms, $50 \div 2$; $2\overline{)50}$; $\frac{50}{2}$; $50 \times \frac{1}{2}$; half of fifty; fifty divided by two and fifty shared into two are equivalent. In straight-forward mechanical arithmetic in a familiar notation the deaf do not lag so far behind.

The present study used three tests of numerical ability namely:- Number Perception Test 20, which depends on perceptual recognition of numbers; The Four Rules Test 21 which is a non-verbal test of simple mechanical operations with number, money and length and, finally Vernon's Graded Arithmetic-Mathematics Test which is mainly non-verbal but contains a few items couched in a verbal form.

In the results of test performance on the 11+ battery Test 21 shows significant correlation with all other tests of the battery save the Residual Hearing Variate 33.(TABLE 18). The unrotated factorial analysis of this battery (TABLE 19) shows the high communality of this test in the relatively high loading it obtains on the General Factor I. In the following bipolar factors Test 21 is associated with the non-verbal tests in Factor IV and with the non-oral tests in Factor II.

At the 15+ stage TABLE 20 shows the high correlation coefficient between Tests 21 and 22 (.81) and the substantial relationship between Test 20 and these more direct measures of numerical attainment ($r = .52$ and .64). In the factor solution of TABLE 21, Factor I shows highest loadings on these three tests of various aspects of numerical ability. Factor I also shows substantial loadings on lipreading variates 13 and 23. Tests 21 and 22 also reveal substantial loadings on Factor VIII (lipreading). This connection of number and lipreading probably owes a lot to the rôle of seriation aptitudes common to each and the influence of visual perception in Test 20 also establishes a link between these two apparently dissimilar areas of attainment. Another link with verbal factors is provided by Test 22 which has a higher loading on Factor XI (vocabulary) than the more mechanical number tests.

All the number tests correlated significantly with all other tests in the battery save for the Residual Hearing Variate 33 and, in the case of Test 21 only, the only two non-significant correlates were Variates 9 and 23. Before rotation, the highest loading on the first general factor was Vernon's Arithmetic-Mathematics Test 22. Thus the importance of numerical tests as indicators of general attainment seems established as does the likelihood of positive transfer of training to non-numerical areas.

Perceptual Speed

Two tests of number and word perception were included in the 15+ battery administered to Group C. These two tests, although different in content, each took the form of tests previously known to be heavily loaded with a factor of perceptual speed. This P factor was one of Thurstone's original Primary Factors and given the dependence of the profoundly deaf on visual avenues of information it is surprising that no direct attempt to investigate their performance on perceptual speed tests in relation to visual reception of language has been reported in the literature reviewed for this present study.

Tests 19 and 20 have been treated above as language and number tests but they have a common method of administration which emphasises visual discrimination at speed and a reasonably high correlation coefficient of .68 exists between them.

Concomitants of Perceptual Speed

Test 20 is significantly correlated to all other tests in the 15+ battery save Residual Hearing Test 33 and Test 19 is significantly correlated to all other tests save tests 5, 8 and 33. This non-significant correlation with the two memory tests 5 and 8 is the reverse of what might be expected in view of the slight delay introduced between stimulus and response by the H-board apparatus which presumably introduced some component of visual retention into Tests 19 and 20.

The numbers in the categories of the Vision Variate 51 are in many cases too few to permit statistical treatment but the cell values given in the lower part of TABLE 22 indicate that visual acuity may not be completely unrelated to perceptual speed.

Both tests of perceptual speed have high loadings on Factor VIII (lipreading) and the relatively specific Factor IV which is highly loaded on the Formboard Test 9 has loadings on tests 5, 19 and 20 which also utilise visual matching processes. Factor VII which is difficult to identify as a meaningful factor, nevertheless shows the association of Tests 19 and 20 which both have negative loadings on this factor.

In factors where the perceptual speed tests show different loadings, one or the other still reflects the generally high communality of this type of test. For example Test 19 maintains a substantial loading on Factor XI (vocabulary) and Test 20 is among the highest loadings on Factor I (number).

The high communality of perceptual speed tests makes them a useful addition to batteries of general attainment and to test profiles for use in guidance and classification (APPENDICES D and E). In addition, perceptual speed, despite the fact that it did not emerge as a specific factor in the present study, may be used diagnostically through its operation on performance of Tests 19 and 20 to ascertain whether under-development in receptive communication processes is due primarily to perceptual or to linguistic deficiencies.

Intelligence

Previous Work

Oléron (1963) has recently drawn attention to the fact that the early growth of psychometrical method owed much to the demands of teachers of the deaf for a method of assessing the intellectual capacities of their charges. Greenberger, in 1889, recorded a plea for such tests in the American Annals of the Deaf before the term "psychological test" was used by psychologists and long before the construction of the Binet scale brought the French loan-word "intelligence" into common usage. In the first quarter of this century the Pintner-Paterson scale devised for the deaf introduced a new avenue to the assessment of intelligence - the performance test battery. In Scotland the first British performance scale (Collins and Drever, 1936) was standardised on profoundly deaf children from the Royal Institution and Donaldson's Hospital in Edinburgh.

Early surveys of intelligence test performance of the deaf used group tests. Pintner and Reamer, for example, found deaf children to be some two years retarded in non-verbal intelligence test performance compared with the general school population. With the development of individual intelligence tests, however, this inferiority in the deaf has been questioned and use of the Drever-Collins battery indicated that on suitable tests the deaf are not inferior.

More recently studies using the Weschler Performance Scale (W.I.S.C.) (Murphy in Ewing, Ed., 1957) have shown this to be a valid non-verbal approach to the establishment of an I.Q. in deaf children which only marginally puts them at a disadvantage compared with the general population. In Holland an adaptation of the Weschler Performance approach has been made for deaf children and the use of new test materials and clear instructions with ample examples of sub-tests shows that the resultant Snijders-Oomen Non-Verbal Scale (Snijders-Oomen, 1959) is designed by psychometrists with a great deal of insight into the particular difficulties of testing deaf children. This test was standardised on 1054 Dutch children and equivalent norms for hearing children are added for comparison. The standardisation data of this test seems to the present writer to provide the most valid comment on the comparative intelligence controversies to date:-

Deaf Inferior	Both Groups Equal	Deaf Superior
Completion Test 1	Drawing Test 2	Block Design Test 4
Picture Memory Test 5	Sorting Test 3	
Picture Series Test 6		
Figure Analogies Test 7		
Knox Cubes Test 8		

Some psychologists have reported to the present writer the suspicion that the test norms for the S.O.N. scale flatter the deaf thereby promoting the counter suspicion that some testers allow their immediate impressions of backwardness caused by inarticulate, unaesthetic speech or by gesticulating dumbness to outweigh the objective findings of their expertise. The complicated instructions and demands upon skill of administration in this particular test battery, however, make it plausible to expect that examiner reliability would not be high and that testers inexperienced in its particular administration skills would not achieve very accurate results.

Kinds of Intelligence Test

The main difficulties encountered in testing the deaf have been listed above and in the particular field of intelligence tests the difficulties connected with selection of appropriate tests for particular purposes may be added to the list.

In general, verbal intelligence tests are not applicable to the profoundly deaf because of their verbal handicap. Yet case histories known to the present writer have indicated that profoundly deaf children have been "assessed" by the verbally biased Terman-Merril scale and the verbal part of the Weschler scale for children. Written instructions, mime, lipreading and fingerspelling have been employed to convey the content of verbal intelligence tests to deaf children. There is little harm in this practice if the tester is aware that he is making a rough subjective, clinical assessment rather like using Koh's blocks as free play material rather than as part of a standardised psychometric instrument. Again there is no reason why verbal intelligence tests suited to the deaf should not be used as properly standardised instruments but this would involve the establishment of standardised instructions given in an agreed expressive communication mode and, above all, the establishment of different sets of norms for different degrees of hearing loss. In the present study and for all other assessment purposes the present writer prefers to use non-verbal intelligence tests and to estimate verbal skills by separate tests of speech and written vocabulary: norms derived from hearing populations are not applicable to deaf subjects except for certain guidance purposes where a comparison with hearing future school-mates or work-mates may be made in addition to comparison with present school-mates.

Thus no verbal tests feature in the following classification of the different kinds of intelligence tests used in the present investigation:-

Intelligence Tests

Non-verbal — Verbal

Performance — Paper and Pencil

Pictorial — Blocks — Designs — Written Symbols

			Pictorial	Blocks	Designs	Written Symbols
SERIATION	-recall			8		
	-reordering		6			
	series -extrapolation interpolation	multiple choice	7		10,11	
		open ended				12
NON-SERIAL	-recall		5			
	-completion				2	
	-matching		1,3	4,9		

This classification is based on the content and the overt characteristics of tests and the idea that three dimensional materials are more "practical" or "concrete" measures of intelligence probably arose from this kind of quarter-mastering approach to test apparatus.

Temporal Aspects of Tests

A cross-classification on a temporal basis may also be made contrasting Tests 1, 3, 4, 6, 7, 9, 10 and 11, which set out all the information necessary for the solution of problems immediately before the subject, with Tests 5 and 8 which demand recall of given information after a time lag and Tests 12 and 2 which demand a response from experience. But, of course, experience of underlying concepts and principles involved in Tests 3, 7, 10 and 11 facilitates the attainments of accurate responses.

Another temporal aspect of testing is the rate of response to items. The scores on Tests 4 and 9, for example, depend considerably upon speed of working. Tests 11 and 12 are timed tests but scores are largely unaffected by considerations of speed, unlike Raven's Matrices Test 10 which is here administered with a 20 minute time limit. The 20 minute norms for the deaf (TABLE 16) show a greater spread than 20 minute norms for the hearing population but mean scores are almost exactly equal at the 15+ stage. Previous reports of deaf inferiority on the Matrices Test (Oleron, 1950; Murphy in Ewing, Ed., 1957; Costello, 1957) refer to the promulgated untimed version (Raven, 1938) which does not hold the important time variate constant. This introduces an often un-noticed handicap for the deaf.

Experience of temporal sequence and the rate of flow of events in time largely comes via audition. Auditory location and the perception of visual sequences may occur but, in the main, events are seen in space and heard in time. If the ear is, in fact, the dominant organ in the development of a sense of time then it is not unlikely that deafness limits the input of experience of temporal sequences and results in an unusual attitude to time which may for some practical purposes be regarded as a defective sense of time. It is unwise to equate deafness with the experimental sensory deprivation described by Hebb (1949, 1954, 1955) and Vernon (1965) but it is perhaps relevant that a distortion of the time sense occurs in subjects of these experiments. Deaf children very often tackle a group test with vigour and, unlike the sensory deprivation subjects, overestimate the time elapsed and usually complete the test well before the time limit expires. The initial statement of the time allowed for test completion does not have the same meaning for a deaf child as for a hearing child and in group tests, even when such tests are administered individually, the deaf do not allocate time efficiently, finish too soon and thus make a much better showing on the timed rather than the untimed versions of such tests. Occasionally, however, an obsessionally meticulous approach may be observed in the deaf child who declines to go along with the mainstream.

In individual tests the rate of response is not so decisively self-regulated and in practice the time taken is often, perhaps unknowingly, regulated by the tester. The attitude of the tester, the use of a stop watch and the action of marking are quickly appreciated as time cues by most deaf subjects who react by attention to speed or to accuracy where appropriate.

It would seem from the experience of testing deaf children with paper and pencil intelligence tests that a re-examination of the general practice of ignoring the time of completion in the norms of such tests could be profitably undertaken. The provision of different sets of norms for different completion times may improve the accuracy of such tests as estimates of intellectual potential. This modification may incidentally improve the chances of the extravert, who like most deaf children, attacks the test with cavalier disregard of possible errors and makes a good showing in a short time.

Results The full Snijders-Oomen Non-Verbal Intelligence Test battery was given to Group C2 and the P scale of this intelligence test battery with the addition of the Knox Cubes sub-test (Test 8) was given to Group C with the following results:-

			Mean Score	Standard Deviation
P scale.	Block Design	Test 4	34.86	(8.77)
	Picture Memory	Test 5	14.86	(2.44)
	Picture Series	Test 6	21.94	(3.54)
	Figure Analogies	Test 7	14.73	(2.17)
Q scale.	Knox Cubes	Test 8	11.20	(1.54)
	Completion	Test 1	18.83	(2.42)
	Drawing	Test 2	12.36	(2.83)
	Sorting	Test 3	13.95	(2.29)

These results made it possible to derive an S.O.N. Test assessment for Group C as a whole and the mean I.Q. of 103 ∓ 22 showed that this Scottish sample did not differ significantly in performance from the original Dutch standardisation sample.

Concepts and Intelligence

The Sorting Test 3 is regarded above as a constituent part of a non-verbal intelligence scale and, as such, is the least reliable of the eight S.O.N. sub-tests. But this test is extremely interesting in its own right as a measure of the ability to grasp everyday concepts and TABLE 17 shows its verbal and non-verbal correlates in order of magnitude as derived from the small sample of Group C2. The relatively low correlation with the S.O.N. P scale ($r = .33$) and the much higher association with the Matrices Test 10 ($r = .64$) indicates a factor which cuts across the performance/paper classification of intelligence tests. But in general non-verbal written tests of intelligence show higher correlation with Test 3 than do verbal attainment tests. Thus the verbal avenues to the attainment of everyday concepts do not seem to dominate in deaf children and non-verbal and manual communication influences seem to be more important in so far as Test 3 may be taken to represent general concept attainment.

Factorial Analysis and Intelligence

All but three of the non-verbal intelligence tests used in the present survey were included in the factorial analysis of the performance of Group C on the 15+ battery. Of the remaining nine tests of intelligence only Picture Memory Test 5 does not have a positive loading on Factor X which may confidently be identified as a non-verbal reasoning factor (TABLE 21). The only other slight loading of non-verbal intelligence tests on Factor X is that of Picture Series Test 6 which again contrasts with the other intelligence tests in having a higher loading than any of them on Factor VIII (lipreading). Test 6 is the only intelligence test at the 15+ level to use pictorial material which consists of cartoon drawings of people and scenes as opposed to geometrical designs. Picture Memory Test 5 has the highest positive loading on Factor VI and the next highest loadings on this factor are of Tests 4, 6 and 10 which suggests that Factor VI may contrast a spatial visualising ability with a factor based on the mechanical attainment of arithmetic, lipreading and writing skills.

The relative lack of overlap between verbal and non-verbal factors derived from this deaf sample contrasts with the picture which emerged from the factorial study of the verbal and non-verbal scales of the Weschler Intelligence Scale for Children by Maxwell (1959). Unlike the Maxwell study of hearing children, however, the present analysis compares non-verbal intelligence tests with verbal attainment tests and no verbal intelligence tests are included in the battery listed in TABLES 20 and 21. Thus Factor XI, which is quite obviously a verbal factor shows zero loadings for all performance tests save for Memory Tests 5 and 8 which have slight negative loadings. Some overlap is evident, however, in the positive loadings of tests of written intelligence and Test 12 has a substantial loading on this verbal factor, doubtless due to the verbal content of some of its items. Similarly on the non-verbal side Factor X shows loadings on some verbal language tests namely a loading of .22 on Speech Test 14 and Vocabulary Test 16 and a loading of .26 on Manual Communication Rating 26.

The slight difference between performance tests and written tests of intelligence in loadings on Factor XI is not evident elsewhere. The intercorrelations of TABLE 20 show, perhaps more clearly, the similarities between tests which cut across the divisions of "concrete" performance and "abstract" written types of test. For example, Performance Test 7 demands the completion of geometrical designs arranged in two dimensional matrices from a multiple choice of given alternatives. In this it is closely akin to the paper and pencil Progressive Matrices Test 10 and the correlation between these tests ($r = .74$) is higher than any intercorrelations between performance tests or between the three written intelligence tests. Another example may be taken from a comparison of the correlation coefficients of Test 4 which employs three-dimensional blocks with Tests 8 and 9 which also use blocks and with the three written intelligence tests 10, 11 and 12:-

$r_{4,8} = .33$ whereas $r_{4,10} = .67$

$r_{4,9} = .34$ $\qquad$ $r_{4,11} = .54$

$r_{4,12} = .57$

The association between Test 4 and written tests is obviously much closer than with the other block tests and this supports the idea that differences between test performances depend little on overt characteristics such as the materials employed but rather on the processes inherent in the tests which present the opportunity for comparable mental processes in the subject to register. The fact that different tests sample different aspects of mental processes does not preclude the existence of an underlying general factor of intelligence. Again, the fact that the deaf are not handicapped in the processes sampled by Test 10 and yet are seriously retarded in the open ended interpolation-extrapolation processes of Test 12 does not diminish the importance of the latter processes as a component in the non-verbal reasoning Factor X nor does it prevent a substantial correlation between Tests 10 and 12.

Incidental Results

To complete this discussion, some incidental findings of influences upon the intelligence of the profoundly deaf may be recorded. A significant sex difference by biserial correlation coefficient, proved deaf boys to be better in Tests 7 and 10 than deaf girls thus confirming some similar previous results (Myklebust, 1960). The mean scores of Test 10 by the aetiological categories of TABLE 23 shows that the hereditary group registers the best performance on this test. Finally, the influence of personality largely ignored in this cognitive survey is probably more important in testing the intelligence of deaf than hearing children and the wide range of correlations (zero to .52) between Persistence Rating 54 and Intelligence Tests 4 to 12 shown in FIGURE 5 may indicate, inter alia, that some tests are more vulnerable to personality influences than others.

PRACTICAL APPLICATIONS (1) EDUCATION

The foregoing description of the nature and interaction of abilities of the profoundly deaf has been completed with little reference to educational practice. In fact, the factorial analytic method throws light upon many issues and controversies of practical education and suggests solutions based on a broad multi-factor approach instead of the usual inappropriate consideration of an oversimplified model based on a few variates, where irrelevant influences are not partialled out. Several such practical issues may be identified from the relationships set out in the correlation and factor matrices of TABLES 20 and 21 and three of these current questions have been selected to demonstrate the practical applications of this kind of psychometric analysis; they are:-

Is there a divergence between non-verbal intelligence and educational attainment?

What is the influence of residual hearing upon educational attainment?

What is the relationship of oral to manual communication skills?

It may be noted that this approach deals with problems within the profoundly deaf population and is not concerned with the often fruitless comparison with hearing, partially deaf or other handicapped groups, although such comparisons with the present data are incidentally possible.

Performance Tests and Attainment

Simpson (1965) in a survey of the 1947 year group in English schools for the deaf registered surprise at the low proportion of intelligent deaf children to gain admittance to the two selective schools for the deaf in Britain. In reply Askew (1965) presented a correlation matrix of the of the battery of selection test results which indicated substantial negative correlations between non-verbal performance I.Q. and verbal attainment tests and Montgomery (1966a) suggested that these negative relationships were due to selectivity effects. The correlation matrix of TABLE 20 shows no significant negative relationships between performance tests and attainment variates. The correlation coefficients between the performance tests and language tests are, however, quite low. This tendency is even more apparent in Factor X (non-verbal reasoning) which has six zero loadings on language tests. Again, Factor XI (vocabulary) shows slight negative or zero loadings on all performance tests, 4 to 9, as against positive loadings on the written intelligence tests, 10 to 12, and the bipolar Factor VI contrasts performance tests 4, 5 and 6 with attainment variates including Written Composition Rating 25 and the two lipreading variates 13 and 23.

Thus there is some basis for concern at the divergence of intelligence and verbal attainment (Askew, 1965) which suggests that there is a need for educational methods to exploit the abilities of the intelligent child who does not acquire language under present methods of instruction. That this is not merely a question of general scholastic under-attainment is shown by the positive correlation of the numerical tests with intelligence tests.

There is, however, a reservation to be recorded against this conclusion in that slight sex differences in the relationship of verbal to non-verbal tests occur. Biserial correlation coefficients not portrayed in TABLE 20 show that in Group C girls were significantly poorer at the .01 level in non-verbal reasoning (as assessed by the S.O.N. Figure Analogies Test 7 and Raven's Matrices Test 10) and significantly better at the .05 level in written vocabulary (as assessed by the Mill Hill Synonyms Test 16 and Picture Vocabulary Test 17). This interesting difference in the abilities of deaf boys and girls has often been noted in the literature (Myklebust, 1960) and where boys and girls are not assessed separately their slightly divergent ability patterns would tend to reinforce any divergence between non-verbal and verbal tests.

Quite incidentally, the consideration of intelligence and attainment in the deaf throws some light upon the concepts of "potential" and "under-achievement" which are often applied to hearing children. In particular, experience with deaf children suggests that the idea of a measurable individual "potential" apart from environmental influences is a hypothetical abstraction with little relevance to educational or therapeutic realities. Before the development of techniques to elicit speech from the deaf the most intelligent of deaf persons were not merely underachievers in this attainment but non-starters. With the very recent exploitation of residual hearing and electronic visible speech analogues the "potential" of all deaf speakers has been raised, presumably step by step with the invention of each new device, but this does not particularly help the individual of high "potential" who does not have access to such devices.

The Influence of Residual Hearing

A number of studies failing to control the population-defining variate of residual hearing have already been noted above (page 52). In some studies residual hearing is recorded and partially deaf and deaf samples are not confounded but a low cut off point between the "partially" and "profoundly" deaf groups has resulted in including in the profoundly deaf group many who have substantial useable residual hearing (and consequently good speech) together with those profoundly deaf who do not have sufficient residual hearing to exploit in speech training. For example, Gaskill (Ewing, 1957 page 197) used a cut-off point between "partially deaf" and deaf at 60 decibels. More realistically, Wollman (1964) using an operational criterion made his "dividing line" at an average hearing loss of 75 decibels above normal threshold "to separate those children who hear unamplified speech albeit imperfectly and those with more severe impairments who, in the main, have little or no experience of unamplified speech." This cut-off level is equivalent to the 90 per cent hearing loss cut-off level adopted elsewhere (Hood, 1949) and for the purposes of comparison it may be noted that, for each ear considered separately, an even loss of 60 decibels across the speech frequencies is equivalent to a hearing loss of 72 per cent and an even loss of 75 decibels is equivalent to a hearing loss of 90 per cent. The conversion of pure-tone responses to hearing loss for speech frequencies is made via the tables constructed by Fowler and Sabine according to the procedure outlined above in the description of Variate 32.

Another even more realistic educationally operational cut-off point would obviously be that which separated those who cannot perceive speech even with benefit of the powerful standard classroom amplification devices from those who have useable residual hearing which permits the reception of amplified speech. For it is conceivable that a cut-off at the 75 dB level could define a sample whose mean hearing loss was low enough to include a large majority with useable residual hearing and thus the mean hearing loss of the sample, together with its standard deviation should be stated.

Whenever partially deaf or those with useable residual hearing are included in the profoundly deaf sample, results are not applicable to the strictly defined profoundly deaf population which differs considerably in psychometric performance. The assumption of homogeneity even within the profoundly deaf group is questionable and it has been noted (Montgomery, 1966b, 1967a) that profoundly deaf groups with 100 per cent hearing loss in the better ear (e.g. Groups C3 and D2) are notably poorer in speech than the profoundly deaf group as a whole (TABLE 1).

It may be further noted that the inclusion of substantial numbers of those with considerable residual hearing in test samples of the profoundly deaf in addition to producing a misleading representation of the facts, has an important effect on teaching practice by lending specious support for those who maintain that all deaf children should be taught by the oral method (Ewing, 1951; Watson, 1967). Oral methods are not appropriate to the needs of the majority of the sub-group with 100 per cent hearing loss yet teachers in training are not instructed in any other teaching methods and consequently direct most of their efforts towards children with some effective residual hearing. It is easier to maintain the oral position when the non-oral group is spread thinly on the ground, outnumbered by the others and less clearly differentiated. Hence the less strictly the deaf population is defined the more will findings be compatible with the oralist claims.

In the present factorial study, TABLE 20 reveals no significant relationship of hearing with any intelligence, attainment or communication variates save the two speech variates ($r = .52$ and $.36$). Thus within this population with a narrow range of hearing loss, speech is still dependent to a substantial degree upon the possession of residual hearing. No other school subjects are dependent upon residual hearing. In the factor solution of TABLE 21 the relatively specific residual hearing factor with positive loadings on the speech variates has been taken out so that its influence upon other interrelationships has been removed.

Given a substantial relationship between speech and residual hearing the relevance of the oral approach to the communication needs of those without useable residual hearing may be questioned. The present results confirm previous work which indicates that the mean articulation loss for the group with 100 per cent hearing loss is well below the level required for the production of speech which is intelligible to listener or lip-reader. On the other hand, out of this same group with 100 per cent hearing loss, teachers estimate that a majority can communicate fluently by means of the manual alphabet and all but 4 out of 22 can understand manual communication with at least "average competence". Is it not then reasonable to consider the possibility that the majority of those without useable residual hearing might be permitted to acquire an education via an approach which reinforces the oral instruction, which largely eludes them, with the manual method of communication which they largely understand already?

Oral and Manual Communication

It is expedient at this point to emphasise that this study is concerned solely with the prelingually profoundly deaf, that is those whose deafness occurred before the development of infant speech and whose inability to hear their own voices precludes the emergence of natural speech, resulting in a speech handicap which in turn results in a general linguistic retardation. This retardation responds to protracted educational treatment in a few cases and intelligible speech and useable language are developed. More often educational treatment fails to promote reasonably fluent speech and as this becomes apparent as pupils grow older, education becomes increasingly directed along non-oral lines, perhaps still verbally biased by silent reading, lipreading and clandestine use of the manual alphabet but possibly becoming more concerned with non-verbal areas such as artistic, technical, numerical and sporting activities. The increasing divergence of hearing loss and articulation loss as children advance in their school career most likely reflects the fact that many reach their optimal speech plateau between the ages 12 to 15 years (TABLE 8).

By the so-called oral method, which is the official educational treatment throughout Britain, no finger spelling or signing is permitted as it is maintained that manual communication is detrimental to the development of the oral skills of speech and lip-reading. A child cannot, according to this view, pay attention to the lips if looking at the hands, will not trouble to name an object if he is allowed to indicate it by sign or by pointing. These excellent rules for the teaching of oral skills are elevated into general principles of education because of the "natural" approach to the education of the very young: they cannot be confined to speech lessons or lip-reading lessons as under the present methods every lesson is a speech lesson and oral communication must be developed at play, meals and after school in addition to the classroom (Groht, 1958).

Yet despite constant prohibition of manualism in school no less than 71 per cent of deaf children have been estimated (by teachers' ratings) to be able to communicate fluently with the adult deaf by manual methods as against the mere 7 per cent who were estimated to be able to produce fairly fluent speech intelligible to the man-in-the-street (Montgomery, 1966b) (c.f. TABLE 14). The contention that there is a negative relationship between oral and manual communication skills has been questioned by Myklebust (1960), Titova (1961), Quigley and Frisina (1961), Kent (1963), Birch and Stuckless (1964) and the present writer (Montgomery, 1966b).

If there were a genuine negative transfer of training between oral and manual communication attainments then this would tend to produce negative correlations between variates representing performance on these two abilities. But the jump from the evidence of correlation matrices to practical conclusions is permissible only when other influences operating on the relationship of oral and manual communication performance in both the negative and positive direction are taken into account.

For example, the possibility of a "halo" effect must be considered. This effect may occur when raters, using one form on one occasion, generalise from one rating to another thereby influencing the correlation in a positive direction. It is equally possible that teachers' preconceptions of the either/or relationship of oral and manual proficiency could influence the correlations between each in the negative direction. Perhaps a combination of these two effects could result in the stalemate of a zero correlation. The results shown in TABLE 20 indicate that the standardised tests of oral abilities 13 and 14, are significantly correlated to the Manual Communication Rating 26, whereas the ratings of oral abilities 23 and 24 are not. Thus a halo effect operating in favour of a positive correlation between oral and manual ratings seems unlikely and, with this in mind, the usual practice of reversing the direction of some of the rating categories, in order to avoid the halo effect, has not been followed in the "Assessment of Linguistic Abilities" form used in the present study (APPENDIX B): it would be pointless to exaggerate the either/or effect in order to offset a non-operational halo effect.

The either/or effect is reinforced by the "time-available" influence which also tends to promote a negative relationship between oral and manual achievements in that time spent in school on communication skills is limited and thus time spent on one medium of communication is not available for instruction in the other. Between most school subjects positive transfer of training offsets the time available effect and results in positive correlations between subjects.

In general the dominant influence producing the impression of a negative relationship between oral and manual skills is degree of hearing loss. This may be more obvious from the following apriori arrangement:-

	Manual Fluency	Fluency in Lip Reading	Speech Fluency
Hearing	Virtually none	Few	The majority
Partially Deaf	Very few	The majority	Many
Profoundly Deaf	The majority	Some	Few

In the present factorial study where the distorting effects of the residual hearing variate have been diminished, no negative relationships between oral and manual skills are observable in the correlation matrix (TABLE 20) and teachers' assessments of manual communication are positively related to standardised tests 13 and 14, lip-reading and speech, ($r = .34$, .25).

The positive relationship between oral and manual skills was not maintained in the factor solution of TABLE 21 where the teachers' assessments of oral ability were given equal weight with the results of standardised tests. Another influence tending to produce unrelated speech and manual communication factors was the coarse class interval adopted to offset the heavily skewed distribution in the manual communication rating due to the large cluster of pupils in the "fluent" categories, 7 and 8. This coarse grouping probably depressed the communality of the manual communication variate resulting in the emergence of Factor III (manual communication) as a relatively specific factor but with positive loadings on the picture vocabulary tests. In contrast, the speech variates showed positive relationships with most of the language variates, high positive loadings on Factor V (hearing) and Factor VIII (lip-reading) and zero loadings on Factor III.

The alleged incompatibility between oral and manual communication skills is often used as a justification for the prohibition of manual methods by invoking the analogy of bad money driving out the good. Of course there is a practical incompatibility at the classroom level where it is often expedient to prevent manual communication in order to concentrate upon speech training - just as in general language teaching it is natural to discourage the use of French conversation in a Latin lesson. From this it does not follow that oral and manual skills, or for that matter French and Latin skills, are negatively related and, indeed, some positive relationship might be expected on the basis of much similarity of linguistic content.

In fact it would be surprising if positive transfer of training did not exist between communication skills linked by common linguistic ability and the importance of what Costello (1957) calls "richness of inner language" has already been noted. There is no statistical evidence in the literature that a negative relationship between oral and manual attainments obtains and the positive relationships noted in TABLE 20 are confirmed by many investigators. Birch and Stuckless (1964) concluded that the influence of early manual communication, when present, tended to facilitate the development of other language attainments, Morkovin (1960) and Titova (1961) have earlier reported extremely promising results of the early use of manual communication in schools in the U.S.S.R., and Hester (1963) has described the advantages of changing to a combined manual/oral method at the Santa Fé school in New Mexico.

The simultaneous use of manual and oral communication as a means of developing "inner language" implies a belief in the positive transfer of training between these separable abilities. Doctor (1963), Galloway (1963) and Greenaway (1963) have each drawn attention to the advantages of reinforcing oral methods with manual communication in appropriate cases. In the view of the present writer positive transfer of training may be expected between all expressive and receptive communication attainments available to deaf learners, namely:-

Expressive	Receptive
Manual signs	Manual sign-reading
Finger-spelling	Reading finger-spelling
Writing	Reading
Speaking	Residual hearing Lipreading Visible speech-reading (machine)

It follows that a major aim in the education of the deaf could be to facilitate transfer between these processes and to develop organised conceptual patterns which are not anchored exclusively to any single mode of communication.

Summary

The findings of the psychometric analysis of performance of school-leavers on a comprehensive test battery may be summarised thus:-

(1) There is no significant negative relationship between any of the cognitive abilities assessed in this study. More particularly:-

(a) There is no negative relationship between non-verbal intelligence and verbal attainment.

(b) There is no negative relationship between oral and manual communication skills.

(2) Speech development is positively associated with the amount of residual hearing present even within the prelingually, profoundly deaf population.

Some implications of these findings are suggested as relevant to the oral approach to the education of deaf children which is the official method throughout Britain and currently the only method presented to teachers in training:-

(3) The low positive relationship between performance test results and verbal attainment implies a need for alternative educational methods to gear the intelligence of deaf children more effectively to academic achievement.

(4) The alleged incompatibility of oral and manual methods used as a justification for the prohibition of the latter may be questioned.

(5) The techniques for the development of speech in deaf children are notably unsuccessful with the majority of those who have no useable residual hearing.

PRACTICAL APPLICATIONS (2) CLINICAL

The demarcation line between "pure" and "applied" psychology is not always clearly drawn and this is especially true of the psychology of deafness where a strong humanitarian motivation towards the practical application of theoretical knowledge almost invariably exist among researchers. In this chapter some of the theoretical observations and relationships hitherto treated academically have been geared to practical use and developed to accord with clinical needs.

This particular use of the word clinical does not coincide with ordinary professional usage and here the term is used quite literally to indicate applications in diagnostic and guidance clinics for audiometric and speech ascertainment and educational and vocational assessments.

These are outlined below under the following headings:-

1. Pure Tone and Speech Audiometry
2. Diagnosis of Articulatory Disorders
3. Educational Guidance
4. Vocational Guidance

Pure Tone and Speech Audiometry

A diagnostic service which establishes the extent of hearing loss is the assumed preliminary to all other clinical assessments described in this chapter. The importance of residual hearing for the development of speech within the profoundly deaf population has already been noted as has the poor speech attainment of those with 100 per cent hearing loss for speech frequencies: from this follows the importance of regular audiometric assessment of profoundly deaf children as a basis for remedial educational treatment.

The Audiogram-average

How to use the data from the audiogram for diagnostic, placement and educational purposes is not, however, immediately obvious and the problem of relating pure tone audiograms to speech has attracted almost as many solutions as there are investigators. Some seek to establish which frequencies are most important for the understanding of speech often with the aim of predicting speech ability from pure tone audiograms using procedures akin to those reviewed by Kryter, Williams and Green (1962). Again, it is common to attempt to summarise in a single percentage value that data from the audiogram which is most relevant to speech. Fowler and Sabine (Council on Physical Medicine Report, 1947), for example, have devised a method which distils from the pure tone audiogram a "percentage hearing loss for speech frequencies". A number of similar audiogram-average methods variously weight the so-called speech frequencies and the resultants are often assessed against criteria of speech audiometry (reception): Seigenthaler and Strand (1964) have undertaken a detailed comparison of seven such audiogram-average methods and evaluated them against speech reception criteria.

Much of the disagreement in the literature on the relationship of pure tone audiometric data to speech arises from the study of very different populations. Six main sources of difference may influence results, namely residual hearing, kind of hearing impairment, ear selection, age of on-set of hearing loss, age and sex. Populations varying in mean residual hearing will give results which differ accordingly. Kryter, Williams and Green (1962), for example, studying a population with slight hearing defects concluded that "an average of pure tone decibel hearing losses at 1000, 2000 and 3000 cps. would be a reasonably valid method for equating the ability of hard of hearing persons to understand everyday speech" although their own findings favoured the frequencies 2000, 3000 and 4000 cps. Quiggle, Glorig, Delk and Summerfield (1957) and Harris, Haines and Myers (1956) asserted that the frequencies 500, 1000 and 2000 were most operative in speech reception of hard of hearing populations. But the presence of some severely deaf cases in the sample could account for the significantly lower frequency range. Seigenthaler and Strand (1964) studying a clinical population composed largely of hard of hearing cases but ranging from mild to profound hearing losses confirmed the choice of 500, 1000 and 2000 cps. as "speech frequencies" but found optimal multiple correlation with speech reception performance when an average of the best two thresholds on these frequencies was employed.

Another source of population variation leading to apparently conflicting results is obviously the kind of hearing impairment of populations under study. The relative ease with which speech is acquired by the person with a uniform hearing loss at all frequencies, compared with the person who has uneven losses at different frequencies, greatly influences the speech reception performance which in turn determines which are to be the "speech frequencies". In a population subject to noise-induced deafness, Quist-Hanssen and Steen (1960) reported wide discrepancies between the A.M.A. (Council on Physical Medicine Report, 1947) and the Harris (1956) audiogram-average calculations and some observed speech thresholds. Their results do not find confirmation in populations differing in kind of deafness (Kryter, Williams and Green, 1962), including that of the present study, and do not seem to be generally applicable.

One source of population variation is ear selection. It is possible to ignore people, as such and to study a population of ears: Kryter, Williams and Green (1962), for example, inspected a sample of 114 people, discarded 66 normal ears, giving a population of 162 hard of hearing ears to assess against measures of speech recognition. The A.M.A. Method (Council on Physical Medicine Report, 1947) assesses a percentage hearing loss for each ear separately, and makes the distinction between better and worse ears for the purpose of combining these into a single percentage hearing loss for speech frequencies for both ears. Another "better ear" concept (Siegenthaler and Strand, 1964) is that which takes the least decibel loss of both ears at each frequency considered separately. Obviously, whether audiometric data is derived from "better ear" per separate frequency, better ear only, both ears, or from both ears grouped separately is a consideration which will influence the interaction of these data with speech criteria.

At the criteria end, one influence which could effect results is the age of onset of hearing loss. The recently deafened may have identical audiograms to the born deaf but their speech would be much more developed and in so far as speech recognition is a learned skill, this advantage would show in speech reception tests. This age of onset variate could be expected to increase in importance with the increase in mean hearing loss of the population chosen for investigation.

The age of the population under study may influence results. Auditory training in Schools for the Deaf recognises that hearing has a certain learned component and the audiograms of deaf children show an improvement, on average, with increasing maturity. Speech reception is also influenced by maturity and, as FIGURE 2 indicates, speech production is influenced quite considerably. The age limits of populations used in previous relevant studies range from 15.6 to 16.2 years (TABLE 1) (Montgomery, 1965) "Adult" (Kryter, Williams and Green, 1962) and 4 years to 87 years (Siegenthaler and Strand, 1964).

Where sex differences occur in independent or dependent variates (TABLE 5) then results could vary according to the proportions of males to females in the sample. An all male sample (Kryter, Williams and Green, 1962), would give results which could be expected to differ from those of a sample balanced in this respect (Siegenthaler and Strand, 1964).

The foregoing population factors could account for much of the difference in the results of various essays in relating pure tone audiometric responses to speech. It may be as well to resolve the differences by settling for results which are applicable to a particular population rather than continue the search for a universally relevant audiogram-average or predictive index. With either a general or particularised approach, however, more meaningful contributions to the problem may be made by the study of samples clearly defined in terms of the population factors listed above.

nalysis of udiometric esponses

An analysis of audiometric responses in relation to speech development in Group D indicated that the profoundly deaf present very different results from those based upon the performance of the more loosely defined deaf population with which most audiogram-average studies have been concerned.

This audiometric-speech analysis of Group D has abandoned criteria of speech reception in favour of speech production as a means of evaluating the relevance of audiometric responses to speech development. Previous tests of the comparable Groups A, B and C covering narrower age limits have indicated that correlation coefficients of between .36 to .53 exist between the A.M.A. audiogram-average assessment, Variate 32, and standardised speech attainment scores of Test 14. Furthermore, many of the profoundly deaf do not develop a large enough auditory vocabulary to sample reliably for assessment by "speech audiometry" or speech reception methods. Even with benefit of amplification devices some never develop a measurable auditory vocabulary: about one quarter of sub-sample D have 100 per cent hearing loss for speech frequencies according to the A.M.A. calculation. Given the absence of significant defect in the speech organs of the majority of the profoundly deaf, their dependence upon suitably amplified residual hearing for speech development, the continual auditory training in relation to speech development and the constant use of powerful amplification devices in school rooms, speech production is an operational criterion more important in its own right in some ways than speech reception. To a great extent the profoundly deaf speaker is able to imitate what is heard and thus speech production is a good guide to speech reception, not only immediate reception but also of steady input over a longer period.

It is perhaps noteworthy that the early training of the profoundly deaf often encourages them to approximate and a speech criterion which does not discriminate between the approximate and the wholly accurate response loses in efficiency. Speech production can be a less approximate criterion than speech reception in this particular group. For example, the child who says "big" in mistake for "pig" gains two points out of a possible three, whereas pointing to a picture or writing a response would gain three out of three. In addition, the estimation of speech production from pure tone audiograms would have useful consequences for the profoundly deaf. Speech problems are more acute for this group than for other deaf persons and an audiogram-average method which was also a good indicator of speech potential would be a useful guide for diagnosis, prognosis and classification for different educational treatments.

The issues which have concerned previous audiogram-average studies are here applied to a sample of the profoundly deaf population. What modifications, if any, would be needed to adapt existing methods to give a summary of audiometric results which would be an appropriate description of residual hearing in this population? What are the most relevant frequencies at which residual hearing contributes to speech development in the profoundly deaf? Is eventual speech performance predictable from the results of the pure-tone audiometric test? These are the questions to which some answers have been attempted below. In addition the analyses of speech and hearing abilities in Group D have been examined for subordinate or particular relationships. Besides the positive correlationship of general measures of speech and hearing many specific relationships prevail. For example, phonemes occur at various relative intensities and in particular patterns on the frequency scale. Again, different hearing defects filter out frequencies in many individual, often irregular, ways.

Tabulation of particular aspects or of the details of the relationship of speech to residual hearing in the profoundly deaf may be of use to those concerned with speech development, therapy or education.

Procedure

The results of binaural pure-tone audiometric tests (Variates 36 to 49) of the 83 deaf children of Group D were compared with their scores on the Phoneme Count, Speech Test 14, the H.L. % A.M.A. audiogram-average estimate (Variate 32) and a Qualitative Diagnosis of speech defect (Variate 28).

Many studies have assumed that decibel loss per frequency band is a variate which is suitable for parametric treatment. Quiggle (1957), Kryter (1962) and Harris (1956), for example, have employed audiometric variates in the derivation of correlation coefficients, Beta coefficients and multiple regression equations. The data of the present study were submitted to processing by a computer programmed to follow this tradition and produced the results shown in TABLE 7 and FIGURE 1. But the binaural group audiogram (TABLE 2), produced in the same print-out, clearly showed a curve which promotes an uneven distribution of responses at some frequencies and the assumption of linearity required for parametric analysis is not wholly valid for this profoundly deaf population as tested by the present instrumentation. In particular, clusters of "no response" entries give a skewed tendency to distributions and the fact that the maximum output at 125 cps, 250 cps and 8000 cps is at 70 dBs, 80 dBs and 80 dBs respectively introduces a false bimodalism which further distorts any linearity which may occur at these frequencies. Nevertheless, with a booster device to record responses well beyond the 100 dB limit of the clinical audiometer used in the present study, these distributions could become suited to parametric treatment and for this reason the parametric approach of TABLE 7 and FIGURE 1 has been retained as a reminder of this possibility for future research in this area: the actual results, however, although not completely meaningless, have been ignored in this study.

In these circumstances the following non-parametric approach has been employed to establish relationships between pure tone audiometric responses and speech production.

(1) A contingency table of responses in decibels per frequency band was compiled and the relative numbers in the "no response" cell compared.

(2) The mean and standard deviation of the % S.P.A.L. criterion of speech was calculated for the numbers in each cps./Dbs. cell of the contingency table. These mean scores give a detailed picture of the speech ability of those who respond or do not respond at ten levels of intensity by seven frequency bands for both ears.

(3) The Chi square test was applied to 2 x 2 tables relating speech (above the mean % S.P.A.L. score, against below the mean % S.P.A.L. score) to a response/no response dichotomy of the seven frequency variates for both ears.

Results

TABLE 2 shows reliable responses as a contingency table. In a few cases it was not possible to elicit reliable responses at all frequencies and no entry is recorded for frequencies where a definite "no response" was not ascertained. Totals for each ear/cps column indicate where the few omissions occur. The four lowest frequency variates have the least number of "no response" entries (especially the 250 and 500 cps. variates) and this is an important feature of their value as indicators of speech ability compared with, for example, the 4000 cps. column which yields no response from half of this sample.

The cell values of TABLE 2 show the numbers upon which the means and standard deviations of TABLES 3 and 4 are based and, obviously, calculations based upon cells containing few cases are more unreliable than those with larger numbers. It should be noted that there is no allowance for interaction between frequencies: each ear/frequency column is considered separately in its relation to the criterion. The means in each audiometric cps/Dbs. category are derived from specific hearing losses at specific frequencies for separate ears and such specific losses, like "islands" of hearing, may or may not be operational upon the general, overall criterion of speech development.

The mean and standard deviation of % S.P.A.L. for audiometric cps/Dbs. categories for both ears is given in TABLE 4. It is apparent from inspection of this table that, in general, an increase in mean articulation loss accompanies hearing loss at all frequency variates for both ears. More particularly, it appears that only very poor speakers do not respond to pure tone audiometric signals at low frequencies and that the gap in speech performance between responders and non-responders is especially marked at 250 and 125 cps. TABLE 6 shows the relationship between dichotomised speech and hearing variates evaluated by the Chi square test. All of the frequency variates for the better ear are significantly related to the speech criterion in so far as this test is applicable. Where expective cell values below the minimum of 5, however, as in the 500 cps and 8000 cps tables, the test does not apply but the relationship portrayed graphically in FIGURE 2 reminds us that speech and hearing are linked within the group responding at 500 cps. Only two of the frequency variates for the worse ear gave significant Chi square values against the speech criterion, namely, the 250 cps and 4000 cps variates. The significant relationship of the 8000 cps variate with the speech criterion was invalidated by an expective cell value below the minimum. Taking significance at the .01 level of probability as a criterion, the frequencies most usefully related to speech, according to this test, are 4000 cps in the worse ear and 2000, 250, 125 and 1000 cps in the better ear. At the .05 level, 250 cps in the worse ear and 4000 in the better ear are significantly related to speech.

A few incidental observations on the relationship of speech to hearing emerged from this study. TABLE 5 indicates that there is no significant difference in % S.P.A.L. and % H.L. (A.M.A.) mean scores between those who have better auditory acuity in the right ear as against those whose left ear is better. Again, the considerably better mean performance of girls on the % S.P.A.L. variate is also shown in TABLE 5 and cannot wholly be explained by the relatively slight sex difference in the same direction in the mean % H.L. (A.M.A.) values. Another difference within this sample is shown in TABLE 1 which indicates that the divergence of mean % S.P.A.L. scores between the sub-group D2 with 100% H.L. (A.M.A.) and the whole of test Group D is such that the assumption of homogeneity of the sample may be questioned.

Discussion

FIGURE 2 and TABLES 2, 3 and 4 give evaluations of different aspects of the relationship of residual hearing and speech development in the profoundly deaf. These relationships may be used as a means of tackling the problem of identifying the pure tone frequencies most relevant to speech development in this group. The "speech frequencies" for the profoundly deaf, on the evidence of this study, appear to include much lower frequencies than found in less deaf populations sampled by comparable studies mentioned above (Kryter, 1962; Siegenthaler, 1964; Quiggle, 1957; Harris, 1956). The pure tone frequencies most usefully associated with the % S.P.A.L. criterion of speech production appear to be 125, 250, 1000 and 2000 cps in the better ear and 4000 cps in the worse ear. It is just as well to note, however, the less marked relationship with the criterion at 125 cps in the worse ear and at 4000 cps in the better ear. The apparent lack of correspondence on the Chi square test between speech and the response/no response categories at 500 and 8000 cps in the better ear may be explained as a result of lop-sided distributions: only 3 better ears registered "no response" at 500 cps and only 8 better ears registered a response at 8000 cps.

The relevance of lower frequencies for speech development in the profoundly deaf may be safely assumed from the results revealed by this sample. Given the association with speech at 4000 cps and noting in addition the generally low articulation loss of the few who respond at 8000 cps (TABLE 4) the importance of higher frequencies for speech in this population cannot be dismissed. Common sense would suggest that residual hearing at 4000 cps and above is utilised efficiently for speech development where it exists but that the majority of the profoundly deaf do not respond at this end of the frequency range and, of necessity, use hearing at the lower frequencies.

The search for "speech frequencies" seems to the present study to be best confined to speech frequencies for particular populations and even within a narrowly defined group such as this, differences occur (TABLE 1) which lead to different "speech frequency" preferences. The fact that speech ability is significantly associated with the 125 and 250 cps variates need not, of course, be interpreted as meaning that these are in any literal sense "speech frequencies" for this group: more realistically they are considered as useful indicators of potential speech ability in a population which is characterised by progressively severe hearing impairment at the higher end of the frequency scale. It would follow from the above results that any audiogram-average method which aims at summarising pure tone audiometric responses as a means of estimating speech potential in the prelingually profoundly deaf could profitably take into account responses below the 500 cps cut-off point of the A.M.A. and other conventions (Siegenthaler, 1964; Quiggle, 1957; Harris, 1956).

TABLE 3 shows the mean and standard deviation of % H.L. (A.M.A.) Variate 32 by audiometric categories in each ear treated separately. Binaural hearing loss may be assumed for all members of this speech-handicapped deaf population and the picture for better and for worse ears is therefore similar. Variates 45 to 48, representing the pure tone responses from 500 cps to 4000 cps in the better ear are not wholly independent of the % H.L. (A.M.A.) criterion, having been used in the first place to establish the % H.L. (A.M.A.) value and thus are not available for statistical treatments demanding experimental independence.

Inspection of TABLE 3 confirms that, in common with other audiogram-average methods, the A.M.A. estimate of percentage hearing loss for speech frequencies is geared to a less deaf population. This is not surprising as the main use of audiogram-average methods is as diagnostic clinical indices intended to aid identification of the various grades of hearing impairment for classification and treatment. Yet an audiogram-average which discriminated more finely within the profoundly deaf group would be a useful clue to differential educational treatment in a group who are not basically homogeneous in respect of speech development.

Another feature of the A.M.A. calculation, which limits its usefulness as a measure of speech ability in the profoundly deaf is the low ceiling of 95 dBs above normal threshold of hearing employed in the conversion tables. In fact, the 100 dBs ceiling of the present study was felt to be too low and given that classroom devices may produce amplification well beyond the 100 dBs level then residual hearing which does not register a response at this level could still be utilised in speech training. Thus an audiogram average method suited to the needs of the profoundly deaf would incorporate responses above the 100 dBs level thereby discriminating between the considerable numbers registering "no response" when the maximum output is 100 dBs.

For many purposes the audiogram-average approach to estimating residual hearing for speech frequencies would be better replaced by a method which directly predicted speech ability from its correlates on the pure tone audiogram. With prelingually profoundly deaf groups there are substantial correlation coefficients between the % H.L. (A.M.A.) variate and speech production (% S.P.A.L.), already quoted above. Furthermore, the results tabulated in TABLE 4 show predictively useful relationships at particular frequencies and intensities. Given this kind of relationship a useful multivariate prediction of the % S.P.A.L. criterion of speech ability could be undertaken.

The validity of prediction of speech from the pure-tone audiogram apparently increases as children progress in their later school career (TABLE 8). This effect is most likely due to the fact that the poorer speakers and so-called "oral failures" early come to a halt in speech development while the better speakers continue to improve and to exploit their residual hearing. This is an unusual feature of speech prediction in that most predictor variates become progressively less valid with the increase in time lapse between prediction and statistical validation.

Obviously, the relationship between speech and hearing may be remote in particular cases, the later deafened child, for example, may register good speech scores and yet be extremely deaf. Again, high intelligence or unusual motivation may enable a profoundly deaf pupil to acquire fluent intelligible speech. On the other hand some 40% to 50% of the profoundly deaf, according to various investigators, have additional handicaps and some 10% to 20% according to a recent estimate of handicaps, such as cerebral palsy and the aphasias, may have direct effects upon the understanding and production of speech (Taylor, 1967): such cases could register low speech scores while yet showing pure tone responses well above the average for the profoundly deaf group.

Undoubtedly there are many factors in speech production which are not covered by the limited data in the pure tone audiogram but, with regard to the subjects of the present study, there is sufficient evidence to show that the relationship between responses to pure tones and speech production is a sufficiently well established tendency in this sample, as a whole, to serve as a basis for prediction. Such a prediction of eventual speech ability from pure tone audiograms would rarely be of high enough validity to be used as a rule-of-thumb classification but as an additional clinical instrument it could be a useful guide to classification problems. Discrepancies between the expective % A.L. value derived from a predictive method applied to the data of the pure tone audiogram and the % A.L. obtained directly from the Phoneme Count may have useful diagnostic implications.

As pure tone audiograms are often available many years before speech develops and speech audiometry is feasible, a statistically validated method of predicting eventual speech performance from audiograms should make it possible to establish an early warning system to discern pupils who would respond to purely oral training from those who would be better aided by additional training in manual communication.

Diagnosis of Articulatory Disorders

The speech and articulation defects and deficiencies of profoundly deaf children are particularly important objectives of remedial educational treatment and demand attention in their own right as well as part of more general educational guidance assessments.

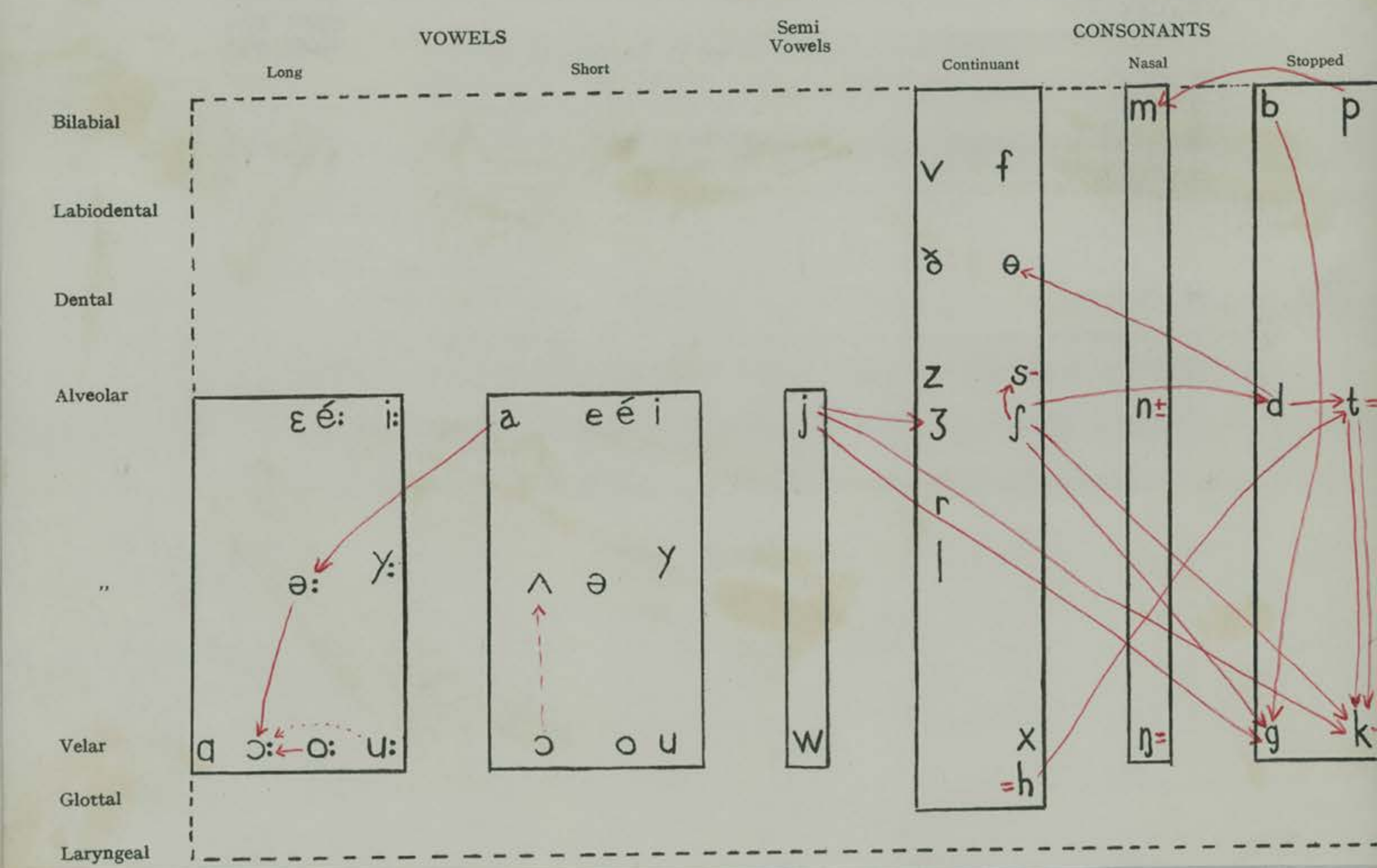
The articulation information of the Phoneme Count Test 14, has been deployed in a simplified graphical form on the Diagnostic Articulation Chart shown in APPENDIX A which has been devised by the present writer to show detailed patterns of articulation loss much as the audiogram portrays the particular constituents of hearing loss.

The main phonemes of Scottish and English speech are arranged in matrices which correspond to variates such as articulatory zone (vertically from bilabial to glottal), height of tongue (left to right within vowels), phonation (left to right within consonants) and duration (left to right between blocks).

Patterns of speech disorder are rarely random and the charting of a referred child's speech pattern on this highly structured speech matrix usually makes clear some characteristic habits which, once made obvious, may be noted for correction. The method of recording individual speech patterns is made quite simply by placing a plus sign for intrusions and a minus sign for omissions against the appropriate phoneme symbol on the Chart and drawing an arrow from a substituted phoneme to the correct phoneme. Under the broad phonetic script employed the majority of errors appear as error substitutes and the arrows on a completed chart show "low pressure areas" where mistakes occur and record the type of error or substitute which is habitually used.

For example, FIGURE 7 shows the pattern of a typical 12 year old profoundly deaf boy with a 46 per cent articulation loss. The cluster of arrows about the stopped velar consonants shows that most error substitutes occur in phonemes formed too far back in the mouth to be visible to lipreaders. Similarly most omissions occur near the velar zone. The use of /j/ and /ʃ/ as favourite substitutes is observable as is one example of the lengthening of the duration of vowels typical of deaf speakers and, on the credit side, the relative absence of error in vowels and voiced continuants.

FIGURE 7



The main use of the Diagnostic Articulation Chart is to present clinical findings in a form which enables teachers to refer easily to particular patterns of speech defects and deficiencies in detail for individual remedial treatment. But whole groups may also be represented on one chart and the differential error tendency of various ability groups thus can be compared graphically. Such a comparison was made for the top, third and bottom ability levels of Group E shown on TABLE 13. Inspection of the completed group articulation charts show that the more intelligible ability levels tend to make error substitutes within a given speech area (horizontal arrows on the chart) as distinct from the less intelligible lower levels who tend to make substitutions between articulation zones (vertical errors).

The implications are clearly that remedial treatment should first aim to reduce the vertical errors which promote unintelligible speech and in conjunction with the order-of-difficulty lists of TABLES 10, 11 and 12 the completed Diagnostic Articulation Chart can convey the information upon which a remedial training program tailored to individuals may be based.

Educational Guidance

Much of the motivation for the present survey of the abilities of deaf children was due to the need to establish norms appropriate to this group on a variety of psychometric tests which could be used, inter alia, to enable sounder educational guidance based on more objective assessments to be undertaken.

Very few of the intelligence tests and even fewer of the attainment tests available in the ordinary child guidance clinic are suitable for use with the deaf. Apparently non-verbal tests may be inseparable from a wealth of verbal instructions and the common enough procedure of squeezing the rare and unfamiliar deaf client through the procrustean hoops of familiar psychometric rituals can rarely be defended even as an example of displacement reaction. The problems facing those asked to provide educational guidance for the deaf may be appreciated better when it is explained that of the varied tests available in the "Diagnostic and Attainment Testing" handbook (Schonell, 1956) which were considered for the present survey test batteries, only the Visual Word Discrimination Test was selected as suitable for the profoundly deaf. Another possible was the Mechanical Arithmetic Test but, in general, the attainment pattern of profoundly deaf children is so different and the same test materials present them with such differing test problems that a completely different approach with new test instruments is usually more profitable than re-norming established tests for the deaf population. The practice of evaluating a deaf child's performance by reference to norms derived from the general population seems to the present writer to be a totally invalid exercise unless a comparison is to be made for the purpose of placement in an ordinary school.

Norms for the profoundly deaf have been established for the cognitive tests described above and listed in TABLE 20 using the present survey sample and varying numbers of other deaf children for each of the tests. These tests, in general, accord well with the teachers' assessments of attainment (TABLES 20 and 21) and greatly objectify the clinical assessment of children referred for individual educational guidance. In addition to this APPENDIX D shows a method of using the 11+ battery for a routine educational guidance mass screening procedure which permits the presentation of a pupil's basic abilities as an Educational Guidance Profile. The scores of individual pupils are transformed into standardised scores by use of a conversion key and marked on the profile.

The standardised score with a mean of 50 and a standard deviation of 10 comprises a T scale where distributions are normal or normalised and thus the scores between tests are directly comparable. Comparison of the four test groupings under Intelligence, Communication, Attainment and Perceptual Speed may help to identify particular areas of difficulty for the pupil and to establish general intellectual functioning. Where unexplained discrepancies occur, additional tests may be employed for further exploratory or confirmatory purposes. It should be noted, however, that with deaf children the concepts of over and under achievement should be used with caution. The specific limitations arising from varying aetiologies have already been described (TABLE 23) and would influence the balance of Intelligence and Communication tests in a few individuals, as would the influence of hearing loss (TABLES 1 and 15). The existence of significant sex differences favouring boys on some non-verbal tests and girls on some verbal tests has also been noted above as a further complication to a simple rule of thumb approach to pupils who are "not working to capacity".

Vocational Guidance

A system of vocational assessment for the deaf has been developed from the results of a follow-up study of eventual occupations of the Group C subjects tested at 15+. Because of the relatively short period, of about one year, between testing and follow-up these results are more valid for the guidance of deaf youths and school leavers than for more mature workers although particular tests may be applicable to the latter. Product moment correlations of Tests 4 to 22 and Variates 33 and 54 were calculated against a criterion of eventual occupational grade, Variate 62, which is largely similar to the "social class" categories adopted by the 1961 census.

A profile of the correlation coefficient of Variate 62 with each of these other variates is shown in FIGURE 5. An alternative occupational grouping equating skilled clerical and manual workers would not give such a high correlation with the verbal tests in the 15+ battery but under the classification of Variate 62 it is the written tests which prove to be the best indicators of occupational status and the exception Lipreading Test 13 does have a substantial loading on the verbal Factor XI (TABLE 21).

It may be noted that some of these tests are "unfair" to the deaf in the sense that a test of colour vision is unfair to the colour blind. Intelligence Test 12, for example demands considerable speed of shift between number, letter and word items to gain good marks within the time limit and deaf children rarely command the flexibility required of this test: again, their difficulty with open-ended seriation tests has been remarked above. Another "unfair" test which has been discussed previously is the Mill Hill Vocabulary Scale which consists almost entirely of abstract vocabulary which is rudimentary in the typical profoundly deaf person. Both of these tests show differences in performance between deaf and hearing populations and both are particularly valid indicators of occupational status. It is hard to escape the conclusion that tests which are not adapted to the deaf are more useful for vocational guidance purposes than those, for example most performance tests, in which they are not obviously handicapped. After all the deaf in Britain are not cossetted in sheltered workshops but must hold their own with hearing work-mates in an occupational setting developed for and by the hearing: the closer their abilities approximate to the hearing, the easier they will be able to adapt to working conditions and the more likely they will be to attain the higher occupational grades.

Vocational Guidance Profile

The Vocational Guidance Profile given at APPENDIX E shows the 14 tests selected to ascertain abilities most relevant to occupational placement. This test battery is administered as a routine service for Edinburgh school-leavers and is available for others by request. Test results are presented to Youth Employment Officers, Missioners of the Deaf and others concerned with occupational placement in comparable standardised scores marked graphically on this profile. The scale used reduces all tests to a common mean of 50 and a standard deviation of 10 and in a normal or normalised distribution these standardised scores are exactly equal to T scores. A marking key fitted to the profile makes conversion of each of the raw test scores into standardised or T scores a simple clerical task.

Besides the test profile based on norms of the profoundly deaf, additional tests are given comparing individual performance with the standards of the general population. This realistic appraisal is not undertaken in any uncharitable move towards some scientistic ideal of impersonal objectivity but it is ultimately in the best interests of deaf candidates that employers should appreciate their limitations as well as their abilities in order to avoid misplacement in unsuitable occupations. Similarly, any additional handicaps are frankly noted. For example, the results of colour vision tests are given under the "vision" heading and may be the means of preventing individuals with defective colour vision from pursuing unrealistic ambitions in occupations such as certain branches of the paint, textile or printing industries where normal colour vision is essential or occupations such as welding where their doubly precious eyesight would be at hazard.

Although personality factors may be of first importance in vocational assessment, most methods of assessing personality are difficult to apply to the profoundly deaf. Thus no direct description of personality is included in the profile but the indirect operation of some personality features may be discerned in the differential performance on the various groups of tests in the cognitive battery. The close similarity between Teachers' Rating of Persistence (Variate 54) and the Occupational Grade (Variate 62) in the correlational profiles of each in FIGURE 5, however, and the intercorrelation of .455 between these two variates, reminds us of the limitations of a purely cognitive approach to vocational guidance.

Group profiles showing the mean standardised scores of different occupational grades are illustrated in FIGURE 6. Comparison of group profiles with individual profiles derived from test performance may often help to match aspirations more realistically to abilities and to indicate useful vocational possibilities. In those who are already employed, profiles may reveal discrepancies between basic abilities and occupational demands which account for low job satisfaction and suggest re-employment at a different level. For example, FIGURE 8 shows the Vocational Guidance Profile of a youth

FIGURE 8 Vocational Guidance Profile showing Example of Underemployment

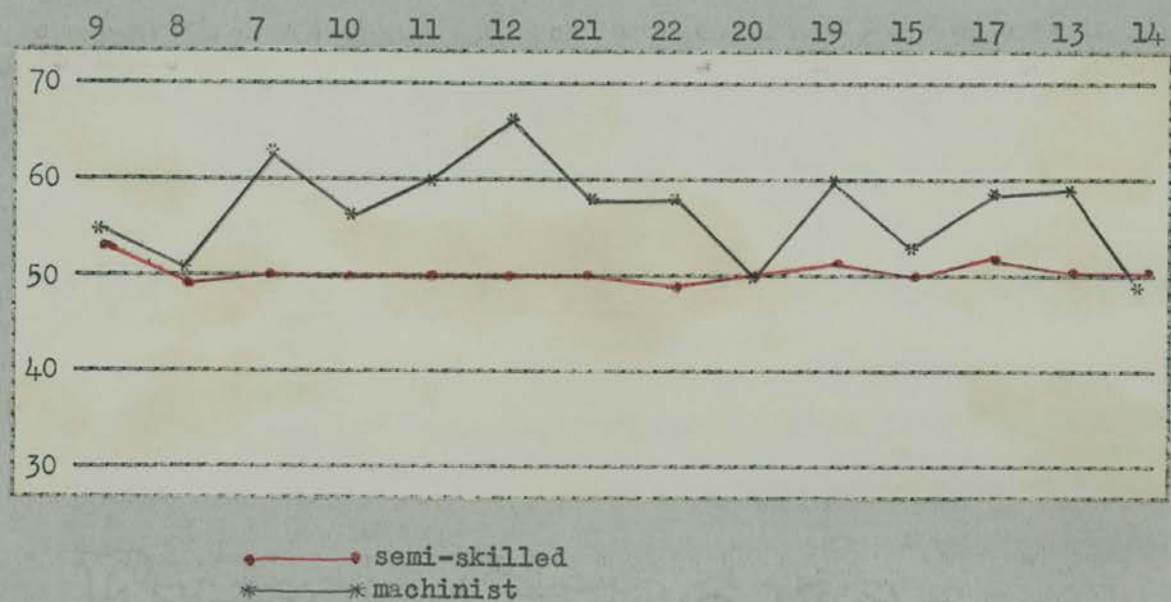
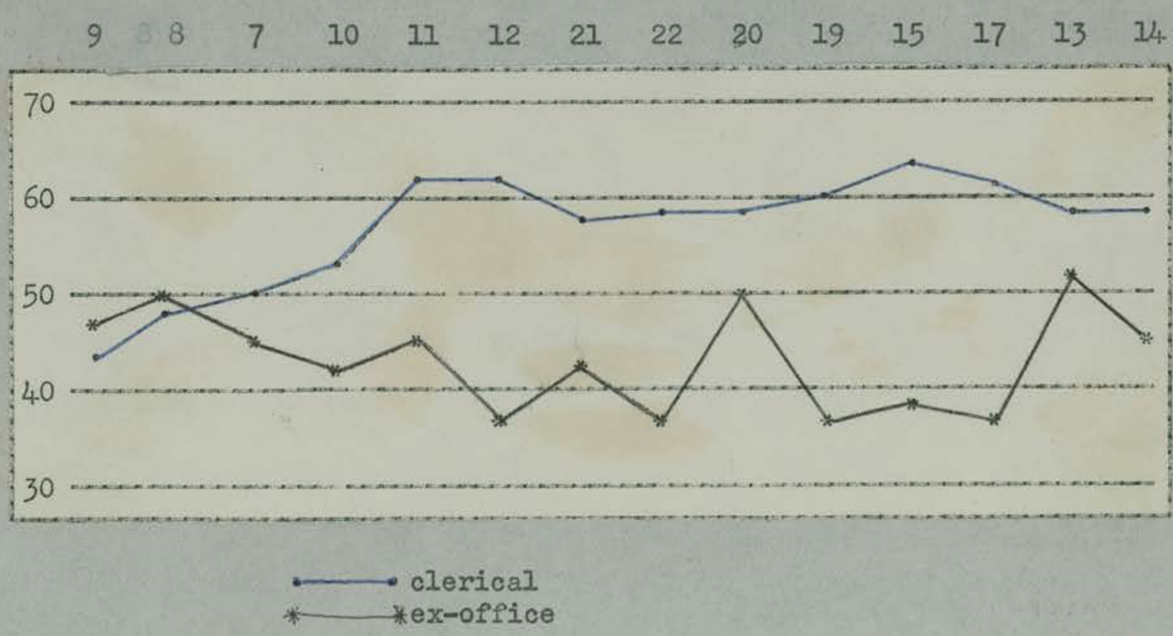


FIGURE 9 Vocational Guidance Profile showing Example of Overemployment



employed at the partly-skilled level as a machine operator. Comparison with the group profiles indicates a closer similarity with the group profiles of the clerical or skilled groups than with the partly-skilled group profile. Subsequent investigation established that this youth was a school dux (captain) and at one time had ambitions to enter university. High scores on some intelligence tests show that these ambitions are not entirely groundless and the profile indicates that some further education or industrial training leading to a more responsible occupation would be worthwhile.

Another example is shown in FIGURE 9 which portrays the Vocational Guidance Profile of a youth of modest attainments who was unable to cope with office work. Comparison with the group profiles indicates similarity with the partly skilled group rather than the clerical group. Re-employment at the partly skilled level was fortunately possible within the same firm but the initial misplacement could have been avoided by a more realistic assessment of the needs of the job in relation to the basic abilities described in the Vocational Guidance Profile.

Although the basis of this system is statistical and in essence what Daws (1966) describes as a "talent-matching model" it does not preclude the therapeutic aspects of vocational counselling, vocational development and after-care. Without the clinician's care for the individual in his own right this system could easily become but a computerised version of Clark Hull's Aptitude-Prediction Machine (Hull, 1928). It is up to the ingenuity of counsellors to overcome the limitations of the blind statistical model and, where necessary, beat the odds.

Occupational Prospects

The psychological appraisal of individuals is but one side of the general problem of placing the deaf into occupations appropriate to their abilities.

Equally important is a knowledge of the basic requirements for occupations open to the deaf and a knowledge of the current employment prospects in general and local prospects in particular. A rough indication of job prospects may be derived from a classification of the 69 members of Group C who replied to the enquiry about current and previous occupations. The following table compares this group with the 10 per cent (Scotland) sample of the 1961 census:-

	Sex	Profoundly Deaf %	Hearing %
Professional	All	0.0	2.3
Intermediate	All	0.0	14.1
Clerical and Sales	Female	10.1	10.8
Craftsmen	Male	23.2	23.2
Semi-skilled	All	39.1	23.1
Unskilled	All	23.2	9.1

All of the deaf in the clerical and sales category are female junior clerical workers so that comparison has been made with the census percentage of female junior clerical and sales workers: some 22.4 per cent of the general female population are in the broader group of clerical workers. Similarly all skilled manual workers were male so that comparison has been made with hearing males only.

Only one deaf person was recorded as having taken up full-time further education (at a technical college) and none have embarked on a career leading to professional status. In this relatively small sample we again find confirmation of the "pitifully small number of placements in the professions" recorded by Oloman (1963) and in fact recognised much earlier in the practical experience of many of his fellow missioners to the deaf.

In terms of sheer numbers, however, the majority of those whose abilities are underemployed belong to the partly and wholly unskilled groups. It is probably worth noting in this connection that extremely little job turnover was reported by the skilled craftsmen alone of the groups under study. A recent enquiry by the Mission to the Adult Deaf and Dumb in the West of Scotland (S. A. D., 1959) confirmed the absence of deaf people in the professions and found the majority of them to be employed in skilled and partly-skilled manual occupations. Again, the 1964 survey of the occupational status of the young adult deaf in New England (Boatner, Stuckless and Moores) found few deaf youths capable of pursuing higher education with success and a very high percentage employed in unskilled and partly-skilled work. Similar surveys are recorded in a recent review of the literature by W. N. Craig and N. H. Silver (1966).

Perhaps the American percentages per occupation group derived from an unprotected labour market are a better guide to the vocational potential of the deaf than figures derived from Britain where the effects of the disablement quota regulations operate. The national survey by Lunde and Bigman in 1959 gave the following comparison between deaf and hearing populations:-

	Deaf %	Hearing %
Professional	6.6	10.6
Managerial	3.2	15.5
Clerical and Sales	7.2	20.7
Craftsmen and Foremen	35.9	13.4
Semi-skilled	35.2	20.1
Unskilled	11.9	19.7

A more recent study of deaf employment undertaken by New York State Psychiatric Institute (1963) presents a less optimistic picture:-

	Deaf %	Men %	Women %
Professional	0.0	0.0	0.0
Clerical	6.0	1.7	13.3
Skilled	57.1	60.6	51.0
Unskilled	30.4	28.9	32.9
Custodial	3.9	4.6	2.8
Own Business	2.6	4.2	0.0

The influence of age, degree of deafness and a partly different classification prevents any strict comparison of American and Scottish figures but the preponderance of manual workers in the deaf group is still marked.

Another clue to occupational prospects for the deaf may be gained from an analysis of job lists used operationally in pastoral work by my colleague S. S. Gordon in Aberdeen and Hull and by R. S. Oloman in York, together with the returns from the current national survey in Scotland. The kinds of jobs available at each occupational level are expressed as a percentage of the total check-list of 177 jobs, thus:-

Professional	3.9
Clerical	7.9
Craftsmen	35.5
Semi-skilled	32.8
Unskilled	19.7

The greatest diversity of jobs available thus seems to exist at the skilled and semi-skilled level and the preponderance of manual occupations already noted by counting heads is confirmed by listing kinds of jobs open to the deaf.

From the combined experience of these sources it would seem unusual if not unwise to employ deaf persons in work involving communicating or dealing with people. Many sales and service occupations which are apparently suitable, such as shop assistant, waiter, assistant beautician, hairdresser or storekeeper demand simple communication skills which, under normal conditions, are essential to efficiency. The deaf seem to excel in craftsmanship, assembly work and operating factory and office machines. A recent gain in the number of office workers relative to other occupational groups may be due to the increased use of data-processing and other machines in offices today. It is often helpful to distinguish between clerical work, data processing and design or drawing office work when making recommendations as very different abilities are required for these categories. Until recent restrictions were introduced in some areas, many deaf persons were apprenticed to a wide variety of trades in the printing industry. From the experience of those accepted in previous years, it seems that deaf workers are quite well suited to the printing industry and in the U.S.A. printing has long been a stronghold of deaf employment, depending especially heavily upon deaf workers during World War II.

Some occupations involve unusual hazards for deaf workers which may not be obvious to the inexperienced. The importance of noting hazards involving defective vision, defective balance and exposure to heavy vehicles in a confined space cannot be ignored in any responsible counselling procedure.

Despite these pros and cons of deaf employment it is as well to note that individuals have been successful in a wide variety of jobs at all occupational levels and the rule is often tested by exceptional ability or exceptional circumstances at particular firms. The recent review of job prospects by Vernon and Fishler (1966) presents an admirable discussion of the problem from the viewpoint of the American experience and despite some local differences the relevance of their recommendations, for example, the suggestion of the suitability of data-processing and litho-offset machine work, is obviously not confined to any one country.

Occupational Placement

A psychometric appraisal summarised on the Vocational Guidance Profile would usually be prepared by a psychologist for the Youth Employment Officer and Missioner for the Deaf (or Welfare worker) in the youth's home area. This team brings to the problem of placement, besides their various professional skills and local knowledge due consideration of individual social and financial circumstances. It is not unusual to find that the individual school-leaver is not personally known to the placement team and it is clear that a standardised objective description of the leaver would be a useful aid to placement which would be preferred by most advisers to the traditional teachers' reports which are inevitably subjective and based upon local rather than national standards.

In order to relate the information of the Vocational Guidance Profile to the problems of placement two additional aids are provided for advisers, namely a collection of group profiles and a search list of occupations derived from the pooled experience of the sources already mentioned. These aids are not reproduced here but are published elsewhere together with the details of applying this method of Vocational Guidance for the deaf (Montgomery, 1967c).

Discussion Reviewing the results of psychometric assessment of the profoundly deaf both as individuals and as a group in the light of the basic requirements established for occupational grades and for particular occupations the immediate impression is that the abilities of the deaf are often underemployed. It is common enough to find boys with the intelligence of an honours graduate apprenticed to a trade demanding average intelligence. Yet without effective application of this intelligence to formal scholastic attainments it is a singularly unexploitable asset in the occupational field and, indeed, may be a liability in routine and monotonous semi-skilled jobs. The experience of psychometric assessment for entrance to the Mary Hare Grammar School (Askew, 1965) has revealed a wide discrepancy between intelligence and attainment which suggests that educational techniques to gear intelligence to scholastic attainment could be developed profitably for academic as well as vocational ends.

Under the paternal cloak of the disablement quota many deaf persons accept work for which they are not particularly suited. Sometimes the folk memory of harsher days gives rise to the conviction, not wholly unjustified today, that any job is better than none causing parents and advisers to accept the first vacancy instead of being more discriminating. Another complication is that the late school-leaving age leaves a narrow time margin in which to acquire apprenticeship agreements in trades where an arbitrarily low age limit is imposed. Often the result of these conditions is low job satisfaction mitigated by reduced vocational aspirations or frequent changes of occupation.

In these circumstances it is worthwhile to emphasise that psychometric investigation reveals many basic abilities and skills in which the profoundly deaf are no worse than the general population and in some tasks demanding fine visual discrimination they are consistently found to be better. Yet, because of their handicap in linguistic skills an unjustifiable generalisation, amounting in some cases to superstition, may be made assuming retardation where it does not exist. In assessors unfamiliar with the problems of the profoundly deaf this attitude may find apparent confirmation where inappropriate tests, say of intelligence or arithmetic, employ spoken or written language and results show an apparent retardation due to the lack of linguistic development.

Basically the problem of employing profoundly deaf people is one of transcending generalisation and matching their particular abilities to particularly appropriate occupations. By appraising the particular abilities of each individual and cataloguing the particular requirements of many occupations it is not unlikely that the systematic approach outlined here will be of use to vocational advisers in their sustained effort to close the gap between occupational potential and current placement prospects. No apology is offered for the lack of parsimony in the Vocational Guidance testing procedure. The peculiar problems of testing deaf children are such that many confirmatory tests are required to give a reliable assessment. Also the greater need of sound appraisal for vocational purposes in this group than in general, together with the fact that there are very few of them, makes a through-going, comprehensive psychometric examination a practical proposition.

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APPENDIX A

A

DIAGNOSTIC ARTICULATION CHART

Name ....

% Articulation loss ....

Date of Birth ....

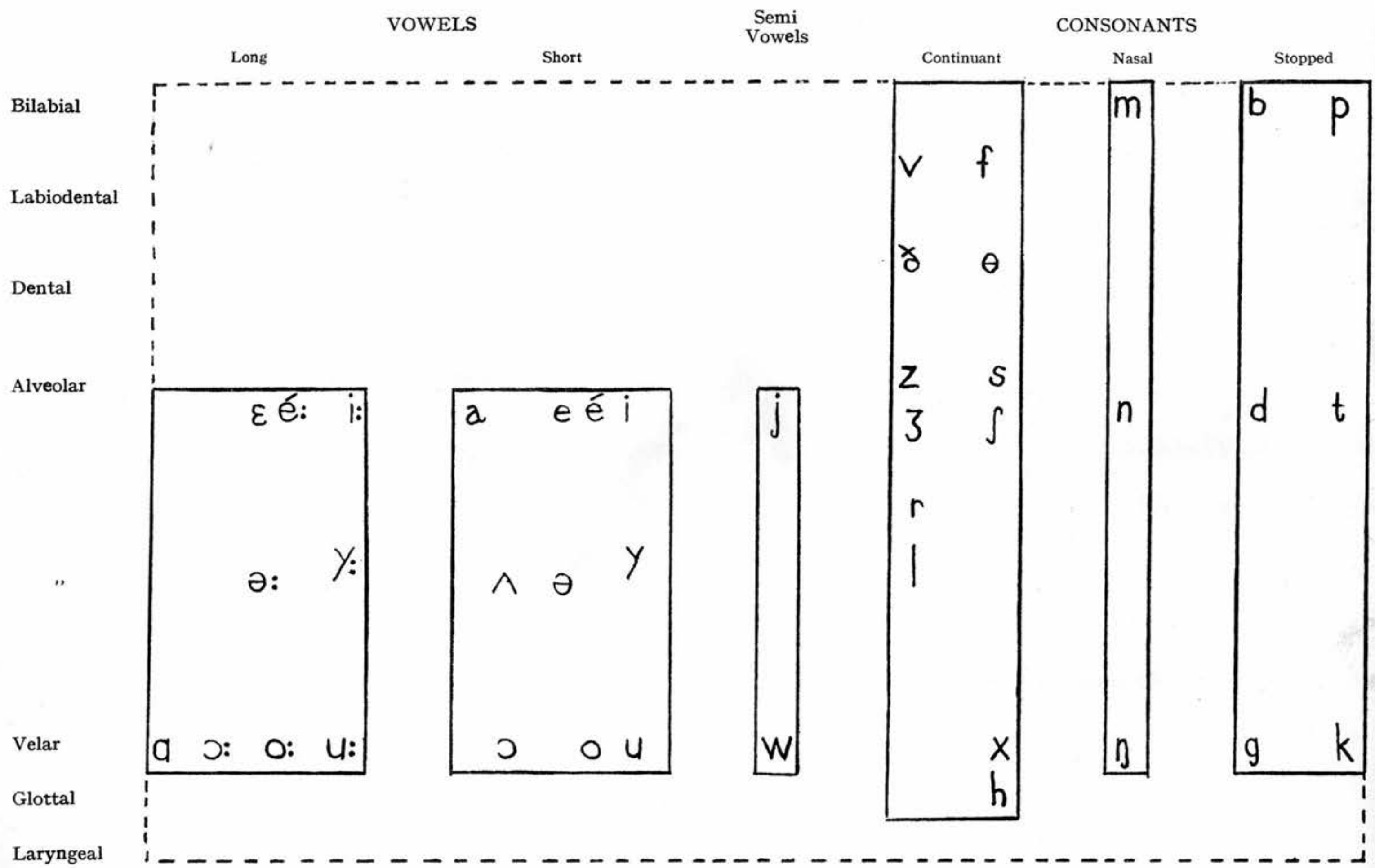
% SPAL ....

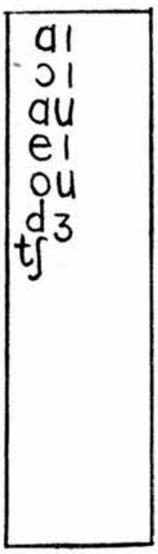
Age ....

Diagnosis ....

School ....

....





NOTES

Date of test ....

Tested by ....

APPENDIX B

ASSESSMENT OF LINGUISTIC ABILITY

Name of Pupil ....

Date of Birth ....

Age ....

Please indicate which statement best describes the pupil by placing a tick at the most appropriate point on the line.

ORAL COMPREHENSION (using personal aid and with speaker's mouth in good light)

No really useful grasp of what people say: recognises a few simple words only.	Can recognise a few commonplace words and phrases when spoken deliberately.	The ordinary deaf child in this respect: average understanding of the spoken word.	Above average but falls short of understanding at the normal conversational rate.	Can follow a normal conversation reasonably well.

VOICE PRODUCTION

Can not produce recognisable words	Very laboured speech which may be understood by those who have taught it. Spoken vocabulary very limited.	Can produce speech which is understood by those familiar with it at home and school.	Speech may be occasionally intelligible to others besides family and teachers.	Can produce fairly fluent speech, intelligible to the man-in-the-street.

WRITTEN COMPOSITION

Virtually illiterate: can write a few simple words only.	Can produce many written words and phrases but does not write in sentences.	Many errors of spelling and grammar but does try to write in sentences if left to own resources.	Writes in simple sentences with occasional grammatical slips.	Can produce good written work in grammatical sentences without assistance.

MANUAL COMMUNICATION

Has no knowledge of finger-spelling.	Has some knowledge of finger alphabet but rarely uses it.	Average competence at understanding finger-spelling.	Can communicate fluently with the adult deaf by using finger alphabet.	Almost total reliance on fingers for means of communication.

Remarks ....

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APPENDIX C

C

Personal Qualities Rating

Name of Pupil . . . .
Date of Birth . . . . .Age. . .
Day/Boarder. . . . .

Please indicate which statement best describes the pupil by placing a tick at the appropriate point on the line.

Exemplary behaviour a credit to school and parents.	A well behaved pupil	Usually keeps within the rules: conduct average	Often troublesome	A nuisance in school. Constantly in "trouble": chronic bad behaviour.

Very lethargic: little sign of life if left to own resources. Verging on the comatose.	Little energy to spare for work or play.	Average energy	Energetic	Over-active: gives impression of untapped surplus energy. Restless need to "let off steam".

At the mercy of almost any distraction, gives up when things get difficult.	Needs to be persuaded or tempted (often by extraneous factors) to keep at it.	The normal pupil in this respect	Persistent: not easily deflected from the job in hand.	A sticker to an outstanding degree cannot be shaken from a course of action by difficulties or distractions.

Passive and "soft". Afraid to assert own rights. Would"give in"or run away rather than stand firm in a quarrel.	Rather slow to assert own rights in any dispute: usually avoids a quarrel.	Will stick up for own rights but believes in the motto "Live and let live".	Easily induced to join in a quarrel but rarely starts trouble.	Aggressive: usually to blame if a quarrel breaks out.

Can not be depended upon, even with supervision and chasing.	Needs constant supervision. Little pride in work.	Needs external incentives from time to time.	Can be depended upon to see things through unchecked by others: has strong inner standards.	Goes out of his way to take on more work and responsibility. Completely trustworthy loyal and dependable.

Lacks confidence to a marked degree: extremely hesitant and dependant upon others.	Hesitant: wary of new people and situations.	Average confidence. "Stands on own feet" most of the time.	A healthy self-confidence and independance of outlook.	Over-confident: usually "leaps before looking".

Resents correction from above.	Some reluctance to correct bad work habits and errors.	Accepts correction and criticism as "necessary evils" without enthusiasm.	Does not mind correction and criticism.	Welcomes well-meant criticism and uses it for self-improvement.

Keeps himself to himself (or herself to herself). Little or no personal relationship with school mates.	Not an easy person to fit into a team but does make some attempt to get on with others.	Passively accepts group standards of behaviour "Goes along with the crowd".	A good team worker, co-operative but happier "in the ranks".	A good team worker, co-operative in a group but capable of leadership also.

Other Personal Characteristics:-

APPENDIX D

EDUCATIONAL GUIDANCE PROFILE

Name ______________________ Date of Birth ______________

School ______________________ Age when tested ______________

TEST BATTERY		Deaf Norms - standardised scores
		20 30 40 av. 50 60 70 80
INTELLIGENCE	3D Form Board (dexterity)	
	A.P.U. Attributes (30 mins.)	
COMMUNICATION	Donaldson Lipreading Test	
	Phoneme Count Speech Test	
ATTAINMENT	Picture Vocabulary A	
	Picture Vocabulary B	
	Arithmetic (Four Rules)	
PERCEPTUAL SPEED	Visual Word Discrimination	
	Number Perception	

ADDITIONAL TESTS

Hearing

Vision

Intelligence

APPENDIX E

VOCATIONAL GUIDANCE PROFILE

Name ______________________ Date of Birth ______________________

Address ______________________ Age when tested ______________________

School ______________________ Occupation ______________________

TEST BATTERY

DEAF NORMS

______

	Standardised Scores	3D Form Board	Knox Cubes	Analogies (S.O.N.)	Matrices (20 mins.)	A.P.U. Attributes	A.P.U. Abstractions	Four Rules Arithmetic	Vernons Mathematics	Number Perception	Word Discrimination	Mill Hill Definitions	Picture Vocabulary A	Donaldson Lipreading	Phoneme Count Speech	Percentile
		PERFORMANCE			WRITTEN TESTS									ORAL		
		INTELLIGENCE						NUMBER			LANGUAGE					
3 sd.	80															
																99
2 sd.	70															
																90
1 sd.	60															
																80
																70
																60
Average	50															50
																40
																30
1 sd.	40															20
																10
2 sd.	30															
																1
3 sd.	20															

ADDITIONAL TESTS **General Population Norms**

Hearing

Vision

Speech

Language

Mathematics

Intelligence

____

Date ______________________